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Personal Accountability Survey

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April 1991

Prepared by the University of Alabama
Tuscaloosa, Alabama for the U.S. Army
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PERSONAL ACCOUNTABILITY SURVEY

D. Runcie, University of Alabama Project Director
D. A. Seaver, Project Manager

April 1991

Prepared by the University of Alabama
Tuscaloosa, Alabama for the U.S. Army
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Pacific Northwest Laboratory
Richland, Washington 99352

PREFACE

The present report is part of a coordinated research initiative sponsored by the US Army Safety Center. The University of Alabama research team is comparing questionnaire responses for the FY 82-83 period to the FY 86-87 period. The primary focus of the project was to assess any changes in personal accountability for accidents which may have occurred between these time periods. In addition, a more sensitive questionnaire was developed so that more information would be available concerning the disposition of those involved in accidents.

EXECUTIVE SUMMARY

The primary goals of the present study were to (a) assess accountability for at-fault accidents in FY86-87 and (b) compare these results with those of an earlier time period (FY 82-83). A survey sent to safety officers gathered information in six major categories for aviation (N-108) and ground (N-76) Army personnel involved: Duty status, collateral investigations, remedial training, unfavorable personnel actions, favorable personnel actions, and subsequent accidents. The US Army Safety Center provided three cause categories: IA--flagrant violations of regulations; IB--nonflagrant violations of regulations; II--system induced errors.

The results of the FY86-87 aviation survey indicate the following:

1. Thirty percent (30) of the accident-involved aviators were no longer on active duty.

2. Seventy-one percent (68 of 96) of the aviation samples were the subject of a collateral investigation.

3. Forty-nine percent (43 of 88) of the samples received no remedial training following the accident.

4. Only 12 percent of aviators in Category IB were disciplined, however, most Category IA personnel received unfavorable actions.

5. Forty-eight percent of aviators who violated regulations (IA and IB) received favorable personnel actions.

The results of the FY86-87 ground survey indicate the following:

1. Thirty-eight percent of these individuals left the service.

2. Most (82%) of these individuals were subjects of a collateral investigation.

3. Thirty-four percent did not receive remedial training following the accident.

4. In Category IB, 78 percent of these at-fault personnel experienced no unfavorable personnel actions. More IA personnel were disciplined than those in other categories. Even in the IA category, however, 29 percent received no unfavorable actions.

5. In the total sample, 28 percent received favorable personnel actions. At-fault personnel were treated the same as those individuals with systems-induced errors.

Did accountability improve from FY82-83 to FY86-87? The following results indicate changes, if any, across years for aviation:

1. In general, more aviators left the service in FY86-87.

2. More personnel were the subject of collateral investigations in FY86-87.

3. Remedial training declined 29 percent across years.

4. The percentage of at-fault aviators (IA and IB) who receive unfavorable personnel actions is relatively stable across years.

5. The percentage of at-fault aviators receiving favorable personnel actions does not change across years.

The following results indicate the trends across the two time periods for ground personnel.

1. More individuals left the service in Categories IB and II in FY86-87.

2 There was a slight drop in collateral investigations.

3. Remedial training declined in FY86-87.

4. A higher percentage of personnel are disciplined in FY86-87.

5. No change is seen unfavorable in unfavorable personnel actions.

A comparison of aviation versus ground unit accountability across years reveal the following trends:

1. Collateral investigations are more prevalent in later years for aviators, but decrease slightly for ground personnel.

2. An important and negative trend is seen in the 29 percent decline in remedial training in FY86-87 across both aviation and ground Army personnel.

3. Except for a slight favorable trend in ground personnel, disciplinary actions have not increased across years.

4. Favorable personnel actions are stable across years.

5. Due to the low base rate, subsequent accidents were not statistically analyzed across years for aviation and ground. However, if the data are summed across the categories, it appears that Category IB personnel tend to have more subsequent accidents. These individuals are also the at-fault group which received little in the way of disciplinary actions.

In summary, the overall picture reveals little or no improvement in accident accountability in the most recent sample. Further, remedial training shows a marked decline in FY 86-87.

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INTRODUCTION

In November 1983 General Thurman, VCSA, directed a review of favorable/unfavorable personnel actions for individuals who were involved in Class A-C aviation accidents during FY 82-83. The United States Army Safety Center (USASC) expanded this review to include Class A ground accidents. Questionnaires were distributed and returned by February, 1984. The results for accidents occurring during the FY 82-83 period showed that (for individuals knowingly and willfully violating regulations/procedures), (a) for aviation there were unfavorable actions following the violation on 18% of the cases and favorable actions on 47% of the cases and (b) for ground accidents there were 32% unfavorable, and 19% favorable actions.

The finding that many individuals involved in Class A accidents subsequently experience favorable actions from the Army resulted in an increased emphasis on personal accountability at the highest levels of Army leadership. The question to be tested is whether the increased emphasis on accountability at high levels of command has resulted in increased personal accountability among those in the field.

The primary goal is to evaluate any change in accountability from the period measured by the first questionnaire to the period measured by the latest questionnaire. In addition to the major question of the presence of any accountability change, a series of more fine-grain analyses were carried out to investigate whether collateral investigations of the accident were conducted, what

kind of action was taken or pending, the kind and degree of training taken following the accident, the nature of any promotions since the accident, and possible involvement in further accidents.

A secondary goal was to improve the questionnaire to (a) reduce ambiguity for the rater, (b) increase the amount of information obtained from raters, and (c) keep the new questionnaire sufficiently similar to the old one so that meaningful comparisons could be made.

Finally, a cross analysis will provide both statistical and graphic information about each item in the questionnaire. In some cases statistics will not accompany the findings because of the small number of observations in some cells. The small number of observations in some of the cells represents a change in the sample size rather than a change in personnel behavior.

Method

Questionnaire Revision

Two surveys used by the U.S. Army Safety Center (USASC) to evaluate personal accountability for accidents were revised and expanded. The revised surveys were then sent to Battelle Memorial Institute and USASC for review. The USASC then field-tested the survey with several former safety officers now stationed at Ft. Rucker and revisions were accomplished.

Sample. U.S. Army personnel who were survivors of an accident where human error was involved were the population studied. The aviation sample was 149 class A-C accidents; 208 questionnaires were sent, 108 returned, for a return rate of 52%. The ground

sample comprised class A accidents with Centralized Accident Investigations; there were 77 cases, 77 questionnaires were sent, 76 returned, for a return rate of 99%. These data were compared to data obtained from the 1983 survey. The earlier surveys involved (a) 75 ground personnel involved in 33 accidents and (b) 864 aviators involved in 509 accidents during FY 1982-1983. This study had an 84% return rate.

Descriptive statistics were obtained across a number of categories for both samples, including commands, investigation types, type and number of favorable/unfavorable actions taken/pending, involvement in other accidents, present duty status, training, and causal role category (See Tables 1 and 2).

Causal Role Categories

These accidents were reviewed by the USASC to determine the causal role of the individuals involved. The following causal role categories were used:

1. Category IA - Knowingly and willfully violated regulations: flagrant.

2. Category IB - Knowingly and willfully violated regulations: not flagrant.

3. Category II - System-induced error, e.g., resulted from inadequate training, written procedures, supervision, etc.

4. Category III - No error, i.e., individual was present but actions were correct.

5. Category IV - Insufficient information, i.e., could not determine individual's role based on accident report.

Analysis

Category IA accident accountability was further investigated as to the overall balance of favorable and unfavorable personnel outcomes. For example, following a Class IA accident, one individual received counseling and shortly thereafter was promoted. In this case, it appears that overall, there was no negative effect of the accident on the person's career. The detailed statistical analyses used for inference purposes are reported in Appendix A.

Analysis of questionnaire responses was conducted. Analysis of each question is based on the no-answering that question (not all questions were answered on all questionnaires).

Data Collection

The surveys were sent to MACOM Safety Offices for distribution and then to safety officers in the units of personnel involved in the accidents. They were instructed to return the survey to the USASC within four weeks.

Follow-up phone calls were made by an officer assigned to the USASC (LTC Sisk) in order to clarify information and increase the return rate. Calls were also made to aviation units by Mr. Alton Boyd of USASC. Despite pre-testing, one question (No. 12) appears to be somewhat ambiguous. This question should be revised in further surveys.

Corrective Action/Recommendations

Appropriate corrective actions were described after examination of the results and consultation with the USASC.

Results

Descriptive Summary: 1986-1987 Aviation Results

1. Duty Status

Thirty individuals (30%) have departed the service. The proportion of departure is similar between those who knowingly and willfully violated regulations--categories IA and IB (28%), and those whose errors were system-induced (Category II) (34%).

On Active Duty (N = 100)

	Category			
Response	IA	IB	II	Total
Yes	4	43	23	70 (70%)
No	2	16	12	30 (30%)
Total	6	59	35	100 (100%)

2. Collateral Investigations

Sixty-eight (71%) of the individuals were subject of a collateral investigation.

Collateral Investigation (N = 96)

	Category			
Response	IA	IB	II	Total
Yes	5	44	19	68 (71%)
No	1	14	13	28 (29%)
Total	6	58	32	96 (100%)

3. Training

Of 88 personnel, 51% (45) received training as a result of the accident. What is important to note is that 49% were given no training as a result of the accident. There is virtually no difference in the proportion of aviators retrained across Categories IA and IB versus Category II.

Received Remedial Training (N = 88)

	Category			
Response	IA	IB	II	Total
Yes	1	29	15	45 (51%)
No	5	23	15	43 (49%)
Total	6	52	30	88 (100%)

4. Unfavorable (Formal) Personnel Actions

For 83% of the individuals involved, no formal unfavorable actions were taken. Fifty (89%) of the 56 individuals who knowingly and willfully violated regulations (1B, non-flagrant) experienced no reported negative consequences as a result of their unsafe actions.

For the most flagrant (IA) violations, however, only one of six (17%) aviators failed to receive one or more disciplinary actions.

Unfavorable (Formal) Personnel Actions (N = 92)

	Category			
Response	IA	IB	II	Total
Yes	5	6	5	16 (17%)
No	1	50	25	76 (83%)
Total	6	56	30	92 (100%)

5. Favorable Personnel Actions

Of the 99 personnel involved, 46 (46%) have experienced favorable personnel actions since the accident. Thirty-one of these aviators knowingly and willfully violated regulations (IA and IB). The percentage of aviators in the at-fault categories who receive favorable actions (48%) is equivalent to that of personnel in Category II (44%).

Three of six IA-Category personnel received favorable actions.

Favorable (Formal) Personnel Actions (N = 99)

	Category			
Response	IA	IB	II	Total
Yes	3	28	15	46 (46%)
No	3	31	19	53 (54%)
Total	6	59	34	99 (100%)

6. Other Accidents

Of the total sample, seven aviators were involved in at least one subsequent accident (7%). The small number of cases makes comparisons difficult across categories. However, six of the seven personnel came from category IB.

Other Accidents (N =97)

	Category			
Response	IA	IB	II	Total
Yes	0	6	1	7 (7%)
No	6	52	32	90 (93%)
Total	6	58	33	97 (100%)

Descriptive Summary: 1986-1987 Ground Results

1. Duty Status

Twenty-nine individuals (38%) of these 76 personnel have departed the service. The proportion of departures is fairly similar between those who knowingly and willfully violated regulations--categories IA and IB (37%), and those whose errors were system-induced (Category II) (43%). There are no statistically significant differences across categories.

On Active Duty (N = 76)

	Category			
Response	IA	IB	II	Total
Yes	8	26	13	47 (62%)
No	6	14	9	29 (38%)
Total	14	40	21	76 (100%)

2. Collateral Investigations

Fifty-six (82%) of 68 individuals were subjects of a collateral investigation. Differences between categories are not statistically significant.

Collateral Investigation

	Category			
Response	IA	IB	II	Total
Yes	12	28	16	56 (82%)
No	1	8	3	12 (18%)
Total	13	36	19	68 (100%)

3. Training

Of 70 personnel, 46 (66%) received training as a result of the accident. What is important to note is that 34% of these individuals were given no training following the accident. There is little difference in the proportion of personnel retrained in Categories IA and IB (67%) versus Category II (63%).

Received Remedial Training

	Category			
Response	IA	IB	II	Total
Yes	11	25	10	46 (66%)
No	3	15	6	24 (34%)
Total	14	40	16	70 (100%)

4. Unfavorable (Formal) Personnel Actions

For 70% of the individuals involved, no formal unfavorable actions were taken. Thirty one (78%) of the 40 individuals who knowingly and willfully violated regulations experienced no reported negative consequences of their unsafe actions. In fact, the proportion of IB individuals disciplined shows no statistically significant difference from that of personnel whose errors were system-induced.

Within ground Category IA, we find that significantly more personnel are disciplined than in either of the other two categories. However, four (29%) individuals who flagrantly violated regulations were not disciplined.

Unfavorable (Formal) Personnel Actions

	Category			
Response	IA	IB	II	Total
Yes	10	9	4	23 (30%)
No	4	31	18	53 (70%)
Total	14	40	22	76 (100%)

5. Favorable Personnel Actions

Of the 75 personnel involved, 21 (28%) have experienced favorable personnel actions since the accident. Fifteen (28%) of the 53 individuals who knowingly and willfully violated regulations (IA and IB) experienced favorable personnel actions since the accident. The number of ground personnel in the at-fault categories who receive favorable actions is equivalent to that of personnel in Category II. Four (29%) of the 14 IA-Category personnel received favorable actions. There are no statistically significant differences across the three categories.

Favorable (Formal) Personnel Actions

	Category			
Response	IA	IB	II	Total
Yes	4	11	6	21 (28%)
No	10	28	16	54 (72%)
Total	14	39	22	75 (100%)

6. Other Accidents

Of the 75 individuals, only two ground personnel (Category IB) were involved in subsequent accidents (3%).

Other Accidents

	Category			
Response	IA	IB	II	Total
Yes	0	2	0	2 (3%)
No	14	37	22	73 (97%)
Total	14	39	22	75 (100%)

Descriptive Summary: 1982-83 vs. 1986-87

General Comments

The 1986-87 survey is substantially smaller than the earlier one, especially for aviation, so the proportions may provide the greater amount of information. Furthermore, as only IA, IB and II accident data are available in the 1986-87 survey, the proportions are based upon the ratio of each cell to the total of the three cause categories for both "yes" and "no" responses. This analysis is performed so the results will be comparable to those of the earlier survey. As the "No Response" category does not appear in the later survey, it is dropped in the present comparative analysis.

Additional Comparisons

In addition to the previous proportions, proportions for each of the three categories based upon "yes" and "no" for each question was calculated. This provides the proportion of "yes" and "no" responses for each question and accident category. This analysis supports the above descriptive analysis (see Tables 3 and 4).

Aviation Accident Results

1. Duty Status

The proportions of those departing the service are similar for IA aviators. In categories IB and II the proportion of those leaving the service is significantly larger in 1986-87 as compared to the earlier survey data (see Table 4). Also, overall more of these individuals left the Army (30%) than those personnel (15%) of the earlier survey.

2. Collateral Investigations

For IA accidents collateral investigations were carried out in almost all cases. In 1986-87 there was a shift in proportions indicating relatively more collateral investigations for category II. Overall, more individuals (71%) were the subject of collateral investigations in 1986-1987 than in 1982-1983 (60%). Statistical analyses are presented on pp. 79-86.

3. Training

An important finding is that the overall proportion of aviators given remedial training is reduced from 72% in the earlier sample to 51% in 1986-1987 - a substantial and significant drop. While training is reduced in all three cause categories, the patterns within categories also shift significantly across years. In the later sample, a considerably lower proportion of IA and IB are retrained, whereas only a slightly lower proportion of category II personnel receive retraining than in 1982-1983. These shifts are statistically significant (see pp. 79-86).

4. Unfavorable (Formal) Personnel Actions

In the 1982-1983 sample 82% of IA and IB aviators experienced no formal negative consequences of their unsafe actions. No change is seen in 1986-1987, when 82% of similarly classified personnel were not disciplined. It is obvious that accountability for unsafe accident-related actions has improved little if any since the 1982-1983 period. However, 5 of 6 IA aviators received disciplinary actions in the later period. Statistical analysis (pp. 79-86) revealed no significant changes from 1982-1983 to the more recent survey results.

5. Favorable Personnel Actions

Overall, favorable personnel actions remain the same across the years (47% in early years versus 46% later). However, a drop tends to occur for aviators with system-induced errors, whereas the proportion of IA aviators given favorable treatment rises. This shift in patterns is statistically significant.

6. Other Accidents

There are no significant changes here. It is interesting to note that those involved in IB accidents tend to have more subsequent accidents than the other categories. Due to the low base rate of accidents across time this finding is only tenuous, however, it may be worthy of further research.

Ground Accident results:

1. Duty Status

The proportions of individuals leaving the service since the accident are remarkably similar for (42% and 43%) personnel causing IA accidents. There are more individuals leaving the

service in 1986-87 than in 1982-1983 from categories IB and II (see Table 2).

2. Collateral Investigation

There appears to be a slight drop from earlier years (92% to 82%) in the percentage of collateral investigations. Whereas the proportion of IA and II accidents investigated holds fairly steady across years, a significant relative reduction of investigations is seen in the IB category, i.e., from 96% to 78%.

3. Training

Overall, there is a trend toward less remedial training in the 1986-1987 data. Whereas the proportion of IA personnel trained is essentially equivalent across years, a significant reduction in training (from 81% to 63%) is seen in the other categories (see Table 2).

4. Unfavorable (Formal) Personnel Actions

In 1982-1983, 82% of ground personnel received no formal disciplinary actions. Significantly fewer personnel were not disciplined in the later sample, 70% (see Table 2). This trend toward more individuals receiving disciplinary actions is seen in all categories. However, the largest proportional change toward more actions is seen in the group with system-induced errors (category II) who are not at fault.

5. Favorable Personnel Actions

Overall, there has been virtually no change in the percentage of personnel receiving favorable actions across years. However, category II personnel show a slight proportional drop in favorable actions relative to category IB which slightly increases.

6. Other Accidents

There were no additional subsequent accidents in 1982-83 and only two additional accidents in 1986-87. Individuals from category IB were involved in both accidents.

Comparative Trends Across Years: Aviation versus Ground Accountability

1. Duty Status

Both trends are similar, i.e., an increased proportion of personnel in category IB and II are leaving the Army.

2. Collateral Investigation

Whereas the aviation sample shows an increase in the percentage of collateral investigations across years, the ground data reveals a decrease. However, category IA investigations are high and stable across both aviation and ground.

3. Training

An important and possible dangerous trend is seen in the crucial area of remedial training. Both aviation and ground show a marked reduction in accident-related training from 1982-83 to 1986-1987. Across all categories and both aviation and ground, the percentage of individuals trained falls significantly from 73% to 54% (Chi square = 21.08; $p < .001$). In other words, remedial training given was reduced by 29% in the later years.

4. Unfavorable (Formal)Personnel Actions

Army ground personnel were more frequently disciplined in recent years. However, this was not the case with aviators. Even in the most serious category (IA), where 5 of 6 aviators were given unfavorable personnel actions, a more detailed analysis

shows a lack of accountability. In subsequent months after the accident one aviator was selected for promotion and one was promoted.

In effect, 33% of these personnel received rewards rather than punishment. One aviator received a temporary punishment (loss of PIC status) for several months. The other three individuals were more severely disciplined. It appears that there is a lack of accountability (and thus deterrent effect) in the aviation branch.

5. Favorable Personnel Actions

For both branches of the Army these results reveal no significant nor substantial changes over years for personnel who knowingly and willingly violate regulations (IA and IB).

6. Other Accidents

Due to the low baseline rate of subsequent accidents, it is difficult to evaluate these data statistically across years. In order to better assess these results, the number of personnel in each category were added for both aviation and ground and years. These data are presented below.

Category	IA		IB		II		Total	
	f	%	f	%	f	%	f	%
Yes	2	(4%)	48	(13%)	6	(7%)	56	(11%)
No	50	(96%)	318	(87%)	77	(93%)	445	(89%)
	52	(100%)	366	(100%)	83	(100%)	501	(100%)

A marginally significant trend (Chi Square = 5.51, df = 1, p < .10) was found, reflecting the higher proportion of class IB personnel who have subsequent accidents. This trend appears worthy of further investigation.

Comparison of Actions Taken

Table 5 lists the actions taken for all personnel. This lists Formal Unfavorable Actions, Informal Unfavorable and Favorable Actions. Based on these results a summary table is provided (Table 6). This table lists the types of unfavorable actions taken plus the case where no unfavorable action was taken. In the case of IA Ground accidents it was revealed that where formal unfavorable actions only were taken no subsequent favorable action followed. However, when both formal and informal unfavorable actions were taken, there was one case where a subsequent favorable action was taken and three cases where no favorable action occured.

Summary and Conclusions

The primary goals of the present study were to (a) assess accountability for at-fault accidents in FY86-87 and (b) compare these results with those of an earlier time period (FY 82-83). This summary presents the major findings for the FY86-87 surveys, followed by a summary of comparative trends across aviation and ground and years.

The results of the FY86-87 aviation survey indicate the following:

1. Thirty percent of accident-involved aviators were no longer on active duty.

2. Seventy-one percent of these aviators were the subject of a collateral investigation.

3. Forty-nine percent of these individuals received no remedial training following the accident.

4. Only 12% of aviators in Category IB were disciplined, however, most Category IA personnel received unfavorable actions.

5. Forty-six percent of aviators who violated regulations received favorable personnel actions.

The results of the FY86-87 ground survey indicate the following:

1. Thirty-eight percent of these individuals left the service.

2. Most (82%) of these individuals were subjects of a collateral investigation.

3. Thirty-four percent did not receive remedial training following the accident.

4. In Category IB, 78% of these at-fault personnel experience no unfavorable personnel actions. More IA personnel were disciplined that those in other categories. Even in the IA category, however, 29% received no unfavorable actions.

5. In the total sample, 28% received favorable personnel actions. At-fault personnel were treated the same as those individuals with systems-induced errors.

Did accountability improve from FY82-83 to FY86-87? The following results indicate trends across years for aviation:

1. In general, more aviators left the service in FY86-87.

2. More personnel were the subject of collateral investigations in FY86-87.

3. Remedial training declined 29% across years.

4. The percentage of at-fault aviators (IA and IB) who receive unfavorable personnel actions is relatively stable across years.

5. The percentage of at-fault aviators receiving favorable personnel actions does not change across years.

The following results indicate the trends across the two time periods for ground personnel:

1. More individuals left the service in Categories IB and II in FY86-87.

2. A slight decline is seen in collateral investigations.

3. Remedial training declined in FY86-87.

4. A higher percentage of personnel are disciplined in FY86-87.

5. No change is seen in favorable personnel actions.

A comparison of aviation versus ground unit accountability across years reveal the following trends:

1. Collateral investigations are more prevalent in later years for aviators, but decrease for ground personnel.

2. An important and negative trend is seen in the 29% decline in remedial training in FY86-87 across both types of units of the Army.

3. Except for a slight favorable trend in ground units, disciplinary actions have not increased across years.

4. Favorable personnel actions are stable across years.

5. Due to the low base rate, subsequent accidents were not statistically analyzed across years and branches. However, if the data are summed across these categories, it appears that Category IB personnel tend to have more subsequent accidents. These individuals are also the at-fault group which received little in the way of disciplinary actions.

In summary, the overall picture reveals little or no improvement in accident accountability in the most recent sample. Further, remedial training shows a marked decline in FY86-87. It appears that the increased emphasis on accountability instituted at the highest levels of command in 1983 is not reflected in later actions by field commanders.

Recommendations for Corrective Actions

From the preceding report it is clear that penalties do not automatically and consistently follow "knowing and willful" violations of procedures. For accountability to become a general and accepted practice, penalties for willful and knowing violations must be administered in a consistent and timely fashion. At the same time it is recognized that some errors are the result of high levels of motivation in good Army personnel. It is important that violations of procedures do not stop advancement in an otherwise promising career; at the same time it must be also recognized that violations of procedures will slow career advancement.

The following recommendations are based on the presumption that error classification (i.e. IA, IB, and II) is reliable and valid.

1. A summary of this report should be distributed at command levels.
2. Increased emphases on accountability should be induced at unit command levels--especially in the aviation branch. Make certain that those who are involved with an at-fault regulation-violation accident receive proper counseling, remedial training, etc.; it should be emphasized that failure on the part of supervisory personnel to see that this is done will be considered a failure of accountability also, and methods to encourage supervisory compliance should be considered.

3. Forty-eight percent of aviators and 28% of ground personnel (who had violated regulations) were later given favorable personnel actions. These percentages should be considerably lower.
4. A considerable number of individuals received little or no discipline following an at-fault accident involving a rule violation, e.g., only 11% of the aviatiors in category IB were disciplined. More consistent and predictable (even if not heavy) disciplinary actions are warranted.
5. Remedial training should be a mandatory outcome of all at-fault accidents, unless the individual is grounded, transferred, or otherwise removed from his or her current job assignment.
6. The overall balance of favorable and unfavorable actions should be considered. One aviator who flagrantly violated regulations was given "formal counseling" and then promoted. Obviously, such an example is more of a model than a deterrent.

Table 1
Frequency and percentages by years for each question

AVIATION
Frequency and Percentages

Is this individual still on active duty?

		IA		IB		II		TOTAL	
1982	Yes	17	3.9%	296	67.9%	63	14.4%	376	86.2%
1983	No	5	1.1%	51	11.7%	4	0.9%	60	13.8%
1986	Yes	4	4.0%	43	43.0%	23	23.0%	70	70.0%
1987	No	2	2.0%	16	16.0%	12	12.0%	30	30.0%

Was this individual subject of collateral investigation?

1982	Yes	20	4.6%	178	41.2%	26	6.0%	224	51.9%
1983	No	1	0.2%	164	38.0%	43	10.0%	208	48.1%
1986	Yes	5	5.2%	44	45.8%	19	19.8%	68	70.8%
1987	No	1	1.0%	14	14.6%	13	13.5%	28	29.2%

Has training been conducted?

1982	Yes	16	3.6%	259	58.9%	42	9.5%	317	72.0%
1983	No	6	1.4%	90	20.5%	27	6.1%	123	28.0%
1986	Yes	1	1.1%	29	33.0%	15	17.0%	45	51.1%
1987	No	5	5.7%	23	26.1%	15	17.0%	43	48.9%

Have Unfavorable personnel actions been taken?

1982	Yes	15	3.5%	50	11.6%	9	2.1%	74	17.2%
1983	No	7	1.6%	293	68.0%	57	13.2%	357	82.8%
1986	Yes	5	5.4%	6	6.5%	5	5.4%	16	17.4%
1987	No	1	1.1%	50	54.3%	25	27.2%	76	82.6%

Have Favorable personnel action been taken?

1982	Yes	5	1.2%	166	38.3%	39	9.0%	210	48.5%
1983	No	17	3.9%	179	41.3%	27	6.2%	223	51.5%
1986	Yes	3	3.0%	28	28.3%	15	15.2%	46	46.5%
1987	No	3	3.0%	31	31.3%	19	19.2%	53	53.5%

Has this individual been involved in other accidents?

1982	Yes	2	0.5%	40	10.6%	5	1.3%	47	12.5%
1983	No	16	4.3%	266	70.7%	47	12.5%	329	87.5%
1986	Yes	0	0.0%	6	6.2%	1	1.0%	7	7.2%
1987	No	6	6.2%	52	53.6%	32	33.0%	90	92.8%

Table 2
Frequency and percentages by years for each question

GROUND
Frequency and Percentages

Is this individual still on active duty?

		IA		IB		II		TOTAL	
1982	Yes	7	9.6%	24	32.9%	29	39.7%	60	82.2%
1983	No	5	6.8%	1	1.4%	7	9.6%	13	17.8%
1986	Yes	8	10.5%	26	34.2%	13	17.1%	47	61.8%
1987	No	6	7.9%	14	18.4%	9	11.8%	29	38.2%

Was this individual subject of collateral investigation?

1982	Yes	11	14.9%	24	32.4%	33	44.6%	68	91.9%
1983	No	1	1.4%	1	1.4%	4	5.4%	6	8.1%
1986	Yes	12	17.6%	28	41.2%	16	23.5%	56	82.4%
1987	No	1	1.5%	8	11.8%	3	4.4%	12	17.6%

Has training been conducted?

1982	Yes	9	12.2%	21	28.4%	29	39.2%	59	79.7%
1983	No	3	4.1%	4	5.4%	8	10.8%	15	20.3%
1986	Yes	11	15.7%	25	35.7%	10	14.3%	46	65.7%
1987	No	3	4.3%	15	21.4%	6	8.6%	24	34.3%

Have Unfavorable personnel actions been taken?

1982	Yes	8	10.8%	4	5.4%	1	1.4%	13	17.6%
1983	No	4	5.4%	21	28.4%	36	48.6%	61	82.4%
1986	Yes	10	13.2%	9	11.8%	4	5.3%	23	30.3%
1987	No	4	5.3%	31	40.8%	18	23.7%	53	69.7%

Have Favorable personnel action been taken?

1982	Yes	1	1.4%	6	8.1%	13	17.6%	20	27.0%
1983	No	11	14.9%	19	25.7%	24	32.4%	54	73.0%
1986	Yes	4	5.3%	11	14.7%	6	8.0%	21	28.0%
1987	No	10	13.3%	28	37.3%	16	21.3%	54	72.0%

Has this individual been involved in other accidents?

1982	Yes	0	0.0%	0	0.0%	0	0.0%	0	0.0%
1983	No	12	16.4%	25	34.2%	36	49.3%	73	100.0%
1986	Yes	0	0.0%	2	2.7%	0	0.0%	2	2.7%
1987	No	14	18.7%	37	49.3%	22	29.3%	73	97.3%

Table 3
Frequency and percentages by years for each category

AVIATION
Frequency and Percentages

Is this individual still on active duty?

		IA		IB		II	
1982	Yes	17	77.3%	296	85.3%	63	94.0%
1983	No	5	22.7%	51	14.7%	4	6.0%
1986	Yes	4	66.7%	43	72.9%	23	65.7%
1987	No	2	33.3%	16	27.1%	12	34.3%

Was this individual subject of collateral investigation?

1982	Yes	20	95.2%	178	52.0%	26	37.7%
1983	No	1	4.8%	164	48.0%	43	62.3%
1986	Yes	5	83.3%	44	75.9%	19	59.4%
1987	No	1	16.7%	14	24.1%	13	40.6%

Was training conducted?

1982	Yes	16	72.7%	259	74.2%	42	60.9%
1983	No	6	27.3%	90	25.8%	27	39.1%
1986	Yes	1	16.7%	29	55.8%	15	50.0%
1987	No	5	83.3%	23	44.2%	15	50.0%

Have Unfavorable personnel actions been taken?

1982	Yes	15	68.2%	50	14.6%	9	13.6%
1983	No	7	31.8%	293	85.4%	57	86.4%
1986	Yes	5	83.3%	6	10.7%	5	16.7%
1987	No	1	16.7%	50	89.3%	25	83.3%

Have Favorable personnel actions been taken?

1982	Yes	5	22.7%	166	48.1%	39	59.1%
1983	No	17	77.3%	179	51.9%	27	40.9%
1986	Yes	3	50.0%	28	47.5%	15	44.1%
1987	No	3	50.0%	31	52.5%	19	55.9%

Has this individual been involved in other accidents?

1982	Yes	2	11.1%	40	13.1%	5	9.6%
1983	No	16	88.9%	266	86.9%	47	90.4%
1986	Yes	0	0.0%	6	10.3%	1	3.0%
1987	No	6	100.0%	52	89.7%	32	97.0%

Table 4
Frequency and percentages by years for each category

GROUND
Frequency and Proportions

Is this individual still on active duty?

		IA		IB		II	
1982	Yes	7	58.3%	24	96.0%	29	80.6%
1983	No	5	41.7%	1	4.0%	7	19.4%
1986	Yes	8	57.1%	26	65.0%	13	59.1%
1987	No	6	42.9%	14	35.0%	9	40.9%

Was this individual subject of collateral investigation?

1982	Yes	11	91.7%	24	96.0%	33	89.2%
1983	No	1	8.3%	1	4.0%	4	10.8%
1986	Yes	12	92.3%	28	77.8%	16	84.2%
1987	no	1	7.7%	8	22.2%	3	15.8%

Has training been conducted?

1982	Yes	9	75.0%	21	84.0%	29	78.4%
1983	No	3	25.0%	4	16.0%	8	21.6%
1986	Yes	11	78.6%	25	62.5%	10	62.5%
1987	No	3	21.4%	15	37.5%	6	37.5%

Have Unfavorable personnel actions been taken?

1982	Yes	8	66.7%	4	16.0%	1	2.7%
1983	No	4	33.3%	21	84.0%	36	97.3%
1986	Yes	10	71.4%	9	22.5%	4	18.2%
1987	No	4	28.6%	31	77.5%	18	81.8%

Have Favorable personnel action been taken?

1982	Yes	1	8.3%	6	24.0%	13	35.1%
1983	No	11	91.7%	19	76.0%	24	64.9%
1986	Yes	4	28.6%	11	28.2%	6	27.3%
1987	No	10	71.4%	28	71.8%	16	72.7%

Has this individual been involved in other accidents?

1982	Yes	0	0.0%	0	0.0%	0	0.0%
1983	No	12	100.0%	25	100.0%	36	100.0%
1986	Yes	0	0.0%	2	5.1%	0	0.0%
1987	No	14	100.0%	37	94.9%	22	100.0%

Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable
2037	In Tr	none	none	h.(6)
2040	Ind	none	none	b.
2042	Ind	none	none	h.(1)
2043	Ind	none	none	none
2044	Train	none	none	none
2049	Ind	none	none	none
2050	Ind	none	none	none
2051	Train	none	none	i.
2052	Ind	c. i. k. n.(7)	none	e. i.
2053	Train	none	none	b.
2055	Ind	none	none	b. d.
2058	Ind	a. m.	none	none
2059	In Tr St	none	none	none
2060	In Tr	none	none	b. h.(1,2)
2062	Ind	-	-	-
2090	Ind	a. n.(7)	b. g.	none
2092	Ind	n.(1,2)	d.	h.(1,2)
2093	Ind	none	none	e. i.
2095	In Tr	none	c.	b. h.(1)
2096	In Tr	none	none	none
2099	Ind	none	none	none
2100	-	-	-	c.
2101	Ind	none	none	c.
2102	-	f.	none	none
2103	Ind	n.(1)	none	none
2105	-	none	none	c.
2106	Train	none	b.	b. h.(1,6)
2107	Lead	none	b.	h.(1,6)
2109	Ind	none	none	h.(1)

II Accidents

Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable
2000	Stand	none	none	none
2001	Stand	none	none	none
2002	-	none	none	f.
2003	In Tr	none	none	none
2005	Le Tr	none	none	none
2006	Le Tr	none	none	none
2012	In Tr	none	none	none
2013	In Tr	none	none	none
2016	Le Tr	-	-	none
2017	Le Tr	-	none	none
2021	Ind	none	none	none
2029	-	-	-	e. h.(2)
2032	Ind	d.	none	h.(1)
2033	Le St	none	c.	none
2036	In Tr St	none	none	none
2038	Train	m.	c. d.	h.(1)
2039	Ind	m.	none	b. h.(6)
2041	Train	none	c. d. e.	b. f.
2045	Train	none	none	b.
2046	Train	d.	none	none
2047	In Tr	d.	none	none
2048	Ind	none	none	none
2054	In St	-	-	b.
2056	In Le	none	c.	none
2057	In Le	none	c.	none
2061	Train	-	-	-
2064	Train	-	-	-
2065	Train	-	-	-
2068	Train	-	-	-
2069	Le St	none	none	none
2073	Le Tr	none	e.	b. f. h.(1)
2074	Train	none	none	b. h.(6)
2075	In Tr	none	none	b. e.
2077	Tr St	none	none	none
2082	Ind	none	c.	none
2084	Train	none	none	c.
2091	-	none	c.	h.(2)
2094	In Oth	none	c.	none
2098	-	none	none	b. h.(1,6)
2104	-	none	d.	f. h.(1)

Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable	Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable
			II Accidents						
1001	Lead	none	none	none	1034	Stand	none	none	b.
1006	Train	none	none	none	1039	Lead	none	none	none
1013	Lead	none	none	none	1045	Train	none	none	b.
1018	Stand	none	e.	none	1046	Stand	none	none	none
1022	Lead	m.	none	none	1049	Train	none	none	none
1024	Lead	none	none	none	1052	Train	none	none	none
1025	Lead	none	none	none	1054	Train	d.	none	h.
1030	Lead	j. k.	none	none	1059	Train	none	c.	none
1032	Train	none	none	none	1068	Train	d. g. m.	e.	c. h.
1033	Stand	none	none	none	1070	Stand	none	none	f.
			AVIATION ACCIDENTS						
			IA Accidents						
2025	In Tr	f.	none	c. e. g.	2097	Ind	none	b.	b.
2031	Ind	n.(1)	c.	h.(1)	2108	In Le	c.d.f.g. n.(1, 6)	c.	none
2034	Ind	j.	none	none					
2035	In St	f. h.	none	none					
			IB Accidents						
2004	In Tr	none	e.	none	2063	Ind	-	-	-
2007	Ind	none	none	none	2066	Ind	-	-	-
2008	Ind	none	-	none	2067	Ind	-	-	-
2009	Train	l. m.	none	h.(1)	2070	Ind	none	none	b.
2010	In Tr	d. f.	none	none	2071	Ind	none	e.	h.(2)
2011	In Tr Ot	-	c.	b.	2072	Ind	none	none	none
2014	Ind	none	none	none	2076	In Tr	none	none	e. h.(5)
2015	Ind	none	none	none	2078	In Le	none	none	none
2018	Ind	-	-	-	2079	In Tr	none	none	none
2019	In Tr	none	none	b. h.(1)	2080	Ind	-	-	none
2022	Stand	none	none	none	2081	-	none	c.	none
2023	Ind	none	c.	h.(3)	2083	Train	none	none	none
2024	Ind	none	none	h.(4) i.	2085	Ind	none	none	e.
2026	In St Ot	none	none	none	2086	Ind	none	none	b.f.g.h.(1)
2027	Ind	none	none	i.	2087	In Tr	none	none	none
2028	Ind	none	none	f. h.(1,2	2088	-	none	none	none
2030	Ind	none	none	none	2089	In Tr	none	none	none

Table 5
Listing of individuals by accident type showing actions taken*

GROUND ACCIDENTS

Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable	Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable
			IA Accidents						
1002	Ind	m.	c.	none	1043	Ind	none	none	f.
1016	Ind	b.	none	none	1044	Ind	none	none	b.
1017	Ind	l.	c.	none	1050	Ind	j. m.	none	none
1023	Ind	e. i.	none	none	1061	Ind	d. f.	none	none
1029	Ind	none	none	none	1062	Lead	none	none	e.
1037	Ind	m.	none	none	1063	Ind	f. m.	d. f.	none
1042	Lead	none	none	none	1066	Ind	e.	c.	b.
			IB Accidents						
1000	Ind	none	none	none	1031	Lead	h.	none	none
1003	Ind	none	none	none	1035	Ind	none	none	b. c.
1004	Ind	i.	c	none	1036	Ind	none	none	c. e.
1005	Ind	none	none	b. c.	1038	Ind	none	none	b.
1007	Ind	l.	e.	none	1040	Ind	none	none	none
1008	Ind	none	none	none	1041	Lead	none	none	none
1009	Ind	none	none	none	1047	Ind	none	none	none
1010	Ind	none	none	none	1048	Ind	none	none	none
1011	Ind	none	none	none	1051	Ind	none	none	none
1012	Ind	none	none	none	1053	Ind	none	none	none
1014	Lead	none	none	none	1055	Ind	d.	none	h.
1015	Lead	none	none	none	1056	Ind	none	none	h.
1019	Ind	none	none	none	1057	Ind	d.	none	none
1020	Ind	none	none	e.	1058	Ind	e.	none	b. c.
1021	Ind	none	none	none	1060	Ind	m.	none	f.
1026	Ind	none	none	b. c.	1064	Ind	none	none	none
1027	Ind	none	none	none	1065	Lead	e.	c.	c. e.
1028	Ind	none	c.	none	1067	Ind	d. m.	c. e.	none
					1069	Ind	none	none	none

*Note:
Primary (Human Error) Reason: Individual, Leader, Training, Standards.
Formal Unfavorable, Informal Unfavorable, and Favorable refer to questions #10, #11, and #13; the letters in the columns denote the answers to the question listed by case number.

Table 5
Listing of individuals by accident type showing actions taken*

GROUND ACCIDENTS

Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable	Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable
			IA Accidents						
1002	Ind	m.	c.	none	1043	Ind	none	none	f.
1016	Ind	b.	none	none	1044	Ind	none	none	b.
1017	Ind	l.	c.	none	1050	Ind	j. m.	none	none
1023	Ind	e. i.	none	none	1061	Ind	d. f.	none	none
1029	Ind	none	none	none	1062	Lead	none	none	e.
1037	Ind	m.	none	none	1063	Ind	f. m.	d. f.	none
1042	Lead	none	none	none	1066	Ind	e.	c.	b.
			IB Accidents						
1000	Ind	none	none	none	1031	Lead	h.	none	none
1003	Ind	none	none	none	1035	Ind	none	none	b. c.
1004	Ind	i.	c	none	1036	Ind	none	none	c. e.
1005	Ind	none	none	b. c.	1038	Ind	none	none	b.
1007	Ind	l.	e.	none	1040	Ind	none	none	none
1008	Ind	none	none	none	1041	Lead	none	none	none
1009	Ind	none	none	none	1047	Ind	none	none	none
1010	Ind	none	none	none	1048	Ind	none	none	none
1011	Ind	none	none	none	1051	Ind	none	none	none
1012	Ind	none	none	none	1053	Ind	none	none	none
1014	Lead	none	none	none	1055	Ind	d.	none	h.
1015	Lead	none	none	none	1056	Ind	none	none	h.
1019	Ind	none	none	none	1057	Ind	d.	none	none
1020	Ind	none	none	e.	1058	Ind	e.	none	b. c.
1021	Ind	none	none	none	1060	Ind	m.	none	f.
1026	Ind	none	none	b. c.	1064	Ind	none	none	none
1027	Ind	none	none	none	1065	Lead	e.	c.	c. e.
1028	Ind	none	c.	none	1067	Ind	d. m.	c. e.	none
					1069	Ind	none	none	none

*Note:
Primary (Human Error) Reason: Individual, Leader, Training, Standards.
Formal Unfavorable, Informal Unfavorable, and Favorable refer to questions #10, #11, and #13; the letters in the columns denote the answers to the question listed by case number.

Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable	Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable
			II Accidents						
1001	Lead	none	none	none	1034	Stand	none	none	b.
1006	Train	none	none	none	1039	Lead	none	none	none
1013	Lead	none	none	none	1045	Train	none	none	b.
1018	Stand	none	e.	none	1046	Stand	none	none	none
1022	Lead	m.	none	none	1049	Train	none	none	none
1024	Lead	none	none	none	1052	Train	none	none	none
1025	Lead	none	none	none	1054	Train	d.	none	h.
1030	Lead	j. k.	none	none	1059	Train	none	c.	none
1032	Train	none	none	none	1068	Train	d. g. m	e.	c. h.
1033	Stand	none	none	none	1070	Stand	none	none	f.
			AVIATION ACCIDENTS						
			IA Accidents						
2025	In Tr	f.	none	c. e. g.	2097	Ind	none	b.	b.
2031	Ind	n.(1)	c.	h.(1)	2108	In Le	c.d.f.g.	c.	none
2034	Ind	j.	none	none			n.(1, 6)		
2035	In St	f. h.	none	none					
			IB Accidents						
2004	In Tr	none	e.	none	2063	Ind	-	-	-
2007	Ind	none	none	none	2066	Ind	-	-	-
2008	Ind	none	-	none	2067	Ind	-	-	-
2009	Train	l. m.	none	h.(1)	2070	Ind	none	none	b.
2010	In Tr	d. f.	none	none	2071	Ind	none	e.	h.(2)
2011	In Tr Ot	-	c.	b.	2072	Ind	none	none	none
2014	Ind	none	none	none	2076	In Tr	none	none	e. h.(5)
2015	Ind	none	none	none	2078	In Le	none	none	none
2018	Ind	-	-	-	2079	In Tr	none	none	none
2019	In Tr	none	none	b. h.(1)	2080	Ind	-	-	none
2022	Stand	none	none	none	2081	-	none	c.	none
2023	Ind	none	c.	h.(3)	2083	Train	none	none	none
2024	Ind	none	none	h.(4) i.	2085	Ind	none	none	e.
2026	In St Ot	none	none	none	2086	Ind	none	none	b.f.g.h.(1)
2027	Ind	none	none	i.	2087	In Tr	none	none	none
2028	Ind	none	none	f. h.(1,2	2088	-	none	none	none
2030	Ind	none	none	none	2089	In Tr	none	none	none

Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable
2037	In Tr	none	none	h.(6)
2040	Ind	none	none	b.
2042	Ind	none	none	h.(1)
2043	Ind	none	none	none
2044	Train	none	none	none
2049	Ind	none	none	none
2050	Ind	none	none	none
2051	Train	none	none	i.
2052	Ind	c. i. k. n.(7)	none	e. i.
2053	Train	none	none	b.
2055	Ind	none	none	b. d.
2058	Ind	a. m.	none	none
2059	In Tr St	none	none	none
2060	In Tr	none	none	b. h.(1,2)
2062	Ind	-	-	-
2090	Ind	a. n.(7)	b. g.	none
2092	Ind	n.(1,2)	d.	h.(1,2)
2093	Ind	none	none	e. i.
2095	In Tr	none	c.	b. h.(1)
2096	In Tr	none	none	none
2099	Ind	none	none	none
2100	-	-	-	c.
2101	Ind	none	none	c.
2102	-	f.	none	none
2103	Ind	n.(1)	none	none
2105	-	none	none	c.
2106	Train	none	b.	b. h.(1,6)
2107	Lead	none	b.	h.(1,6)
2109	Ind	none	none	h.(1)

II Accidents

Case Number	Primary Reason	Formal Unfavor	Informal Unfavor	Favorable
2000	Stand	none	none	none
2001	Stand	none	none	none
2002	-	none	none	f.
2003	In Tr	none	none	none
2005	Le Tr	none	none	none
2006	Le Tr	none	none	none
2012	In Tr	none	none	none
2013	In Tr	none	none	none
2016	Le Tr	-	-	none
2017	Le Tr	-	none	none
2021	Ind	none	none	none
2029	-	-	-	e. h.(2)
2032	Ind	d.	none	h.(1)
2033	Le St	none	c.	none
2036	In Tr St	none	none	none
2038	Train	m.	c. d.	h.(1)
2039	Ind	m.	none	b. h.(6)
2041	Train	none	c. d. e.	b. f.
2045	Train	none	none	b.
2046	Train	d.	none	none
2047	In Tr	d.	none	none
2048	Ind	none	none	none
2054	In St	-	-	b.
2056	In Le	none	c.	none
2057	In Le	none	c.	none
2061	Train	-	-	-
2064	Train	-	-	-
2065	Train	-	-	-
2068	Train	-	-	-
2069	Le St	none	none	none
2073	Le Tr	none	e.	b. f. h.(1)
2074	Train	none	none	b. h.(6)
2075	In Tr	none	none	b. e.
2077	Tr St	none	none	none
2082	Ind	none	c.	none
2084	Train	none	none	c.
2091	-	none	c.	h.(2)
2094	In Oth	none	c.	none
2098	-	none	none	b. h.(1,6)
2104	-	none	d.	f. h.(1)

Table 6
Listing of type of unfavorable action taken and whether there was a favorable follow up

GROUND

IA

Unfavorable	Favorable	
	Yes	None
Formal Actions	0	5
Informal Actions	0	0
Formal + Informal Actions	1	3
None	3	2

IB

Unfavorable	Favorable	
	Yes	None
Formal Actions	3	2
Informal Actions	0	1
Formal + Informal Actions	1	3
None	7	20

II

Unfavorable	Favorable	
	Yes	None
Formal Actions	1	2
Informal Actions	0	2
Formal + Informal Actions	1	0
None	3	11

AVIATION

IA

Unfavorable	Favorable	
	Yes	None
Formal Actions	1	2
Informal Actions	1	0
Formal + Informal Actions	1	1
None	0	0

IB

	Favorable	
	Yes	None
Formal Actions	3	3
Informal Actions	5	2
Formal + Informal Actions	1	1
None	19	20

II

	Favorable	
	Yes	None
Formal Actions	2	2
Informal Actions	3	6
Formal + Informal Actions	1	0
None	6	11

Table 7
Comparison of actions taken

AVIATION

Unfavorable actions	1982-83		1986-87	
	Yes	No	Yes	No
Judicial Punishment	1	2	0	0
Non-Judicial Punishment	0	0	1	2
Rescinded/Revoked Orders:				
Pilot-in-Command	8	44	1	3
Instructor Pilot	4	8	0	0
Standardization Instructor Pilot	0	1	0	0
Instrument Flight Examiner	0	1	0	0
Test Pilot	1	1	0	0
Other	0	11	0	0
Letter of Reprimand	3	10	0	4
Bar to Reenlistment	0	1	0	0
Flight Evaluation Board	5	17	0	0
Relieved for Cause	0	3	0	0
Relieved of Command	0	1	1	1
Change of Duty Assignment	3	12	0	0
Denied Promotion	2	2	0	1
Other	4	35	0	0
Favorable actions				
	Yes	No	Yes	No
Promotion	4	233	2	24
Selection for Command	0	14	0	0
Selection for Higher Schooling	0	94	0	5
Awards	0	68	0	3
Selection for Compt. Assgn.	1	20	0	0
Other	0	23	0	0
Appointed on Orders as:				
Pilot-in-Command	0	105	1	8
Instructor Pilot	0	30	0	2
Standardization Instructor Pilot	0	13	0	1
Instrument Flight Examiner	0	10	0	1
Test Pilot	1	18	0	0
Additional a/c qual.	2	28	0	1

Table 7 (Continued)

GROUND

Unfavorable actions	82-83		86-87	
	Yes	No	Yes	No
Judicial Punishment	3	3	1	1
Non-Judicial Punishment	0	0	0	0
Letter of Reprimand	0	3	3	10
Bar to Reenlistment	0	0	0	0
Relieved for Cause	0	1	0	1
Relieved of Command	0	0	0	1
Change of Duty Assignment	0	0	1	1
Denied Promotion	1	1	0	0
Other	4	5	2	4
Favorable actions				
	Yes	No	Yes	No
Promotion	1	9	2	12
Selection for Command	0	1	0	0
Selection for Higher Schooling	0	5	1	3
Awards	0	7	1	3
Selection for Compt. Assgn.	0	2	0	0
Other	0	2	0	3

Appendix A

Description and Analysis of Results

Description of the Analysis for Results obtained from the FY82-83 and the FY 86-87 Aviation Accidents and the Army Ground Centralized Accident Investigations

The analysis below enables us to answer the question whether there has been a significant and important increase in personal accountability in various accident categories over the period from FY82-833 to FY86-87. Also, this will give some indication as to the extent any change has influenced any shifts detected in accident patterns Army wide. We will not only indicate any significant changes in the variables employed in describing aspects of the accident experience as recorded in the returned questionnaires, but in addition, if an effect is numerically important because of the size of any group involved, any interesting statistical indicator will also be included in the final resume.

Our general plan of analysis can be thought of as a bridge structure, i.e., parallel analysis of the results of FY82-83 and FY86-87 and a comparing analysis to determine what factors, if any, demonstrate significant and important changes. We will also indicate whether these changes suggest actual improvement. Besides other descriptive statistics, the surveys of results of the ground and aviation mishap personnel questionnaires for FY82-83 contain the joint distributions of the response variable and the variable representing accident category, one for each of six questions asked on that questionnaire. In the FY86-87

questionnaires there has been some change in both type and number of questions and as a result there has been some change in the number and meaning of the resulting joint distributions. These complications were handled using some techniques of blending parts of data sets. A brief description of methods employed is included in Appendix B. Adjusted data sets have been used for any comparisons made, both in the descriptive and in the technical parts.

Since numerical information is often more intuitively meaningful when presented in graphical form, we have designed a presentation of the joint distribution associated with each question in the questionnaire. This includes a "histogram" in a one dimensional construction. We believe this is helpful in presenting the information in the survey in useful visual form. Each question in our description involves four columns (IA, IB, II and total) and two rows (yes, no). Thus, when we check whether the "action" referred to in each question is indeed different for various accident categories and to what degree, we produce a 4 x 4 matrix whose entries represent "goodness of fit" chi-squares (one degree of freedom) of the response distributions (columns) taken in paris. In total we have produced 24 such matrices, viz., 6 (questions) x 2 (years) x 2 (categories: Ground and aviation). For significance we mark 5% (chi-square > 3.841) and 1% (chi-

square > 6.635). For cross-analysis we have also produced 12 "percentage change in chi-square" matrices as follows. Suppose that M is the chi-square matrix for FY82-83 corresponding to one of six questions and one of two categories. Suppose that N is the corresponding matrix for FY86-87. Define a new matrix (say Q) by taking the entry Qij to be (ij)

$$\frac{Mij}{Nij} - 1 \times 100$$

Notice that "no change in chi-square" corresponds to a value

$$\frac{A}{A} - 1 \times 100 = 0$$

in the matrix. To test for significance we used a one degree of freedom t-test on the variable $\underline{X} = \frac{A}{B} - 1$ (for > 20), then we transform to the appropriate distribution for a two-tailed test with percentage increase (and decrease) the actual variables measured. Thus at 5% significance the readings should exceed 1271 or be less than -91.5. At 1% significance the readings should be greater than 6366 or less than -98.4.

Another table which has been included involves the odds-ratio. Again, given a question and a category, we produce three odds-ratios respectively: IA vs IB + II, IB vs IA + II, II vs IA + IB. The resulting statistic will be discussed later in this appendix. Basically, what it notes is whether being in the base category (base vs. complement) provides "protection" with respect to the "action" considered in the question. For significance questions

we use the corresponding chi-square statistic, the mantel-Haenszel chi-square (one degree of freedom). Furthermore for those preferring 95% confidence intervals, those have also been provided. If the Mantel-Haenszel statistic is significant, but the odds-ratio is contained in the confidence interval nevertheless, then this indicates that at least one of the cell sizes may be on the small side. For consistency in reporting we have always kept with a single statistic. This is so we may compare many disparate pieces of information. The fisher exact test may be used in special cases.

Again, we construct odds-ratio percentages change over questions and categories and test for significance in the same way that was prone for goodness of fit chi-squares to obtain results for significance. The Mantel-Haenszel chi-squares can also be compared this way. As we note from the results obtained there is a strong tendency for the various statistics to reinforce one another, which is of course exactly what is required.

On a Chi-squared based analysis of reponses to a questionnaire.

§1. A questionnaire containing q questions is sent to a population stratified into groups $G_1,\ldots,G_n$. A particular question has possible responses $r_1,\ldots,r_m$ (e.g., m = 3, r_1 = Yes, r_2 = No response, r_3 = No). Thus, for a given question, group G_j produces a sequence σ_j: $\{A_{ij},\ldots,A_{nj}\}$ of non-negative integers. If group G_n is taken to be the total of the stratified groups $G_1,\ldots,G_{n-1}$, then the following analysis includes both stratified and non-stratified aspects. The sequence σ_j corresponding to G_i is the j^{th} column of a display matrix D(G) = D, which represents the analytical information available about the responses to the particular question under consideration.

If we need to consider all the responses simultaneously, then the display matrices can be numbered $D_1,\ldots,D_q$, corresponding to each of the q questions in the questionnaire.

The question we seek to answer is the following: do the responses indicate that "the policy" applied to the groups G_i, which are supposed to be significantly different in composition from each other, is indeed significantly different? To do this we need to look at individual as well as to overall effects, as we shall do below.

§2. As pointed out by J. Oosterhoff in "The choice of cells in Chi-square tests" (Statistica Neerlandica 39(1985), Nr. 2, 115-128), the advantage of using the Pearson χ^2-test statistic in evaluating goodness-of-fit over other methods is that it is easily computed and that it is already satisfactory for rather small sample sizes provided the theoretical probabilities are not themselves widely different. In the situation we shall be dealing with it will not be the case that we can assert that the theoretical probabilities

are not themselves widely different. It will be true however that the χ^2-test statistic maintains its approximate advantages if we compare it with other methods. In our setting we shall therefore take a conservative approach and require cell sizes to be at least 5. Furthermore, since we need to maintain uniformity in the degrees of freedom corresponding to each statistic we cannot pool cells to obtain the minimum cell size 5, but we develop instead another method which accomplishes the same without changing the number of degrees of freedom.

§3. Given response columns $\sigma = \{A_1,\ldots,A_m\}$ and $\tau = \{B_1,\ldots,B_m\}$ corresponding to the i^{th} and j^{th} columns of a particular display-matrix $D = D(G)$, we construct an element M_{ij} of a Chi-squared matrix $M = M(G)$ in the following manner:

If $\min(A_i,B_j) \geq 5$, take

$$\chi^2_{m-1} = \sum_{i=1}^{m} \frac{A_i^2 B}{B_i^2 A} - A, \tag{1}$$

with $A = A_1 + \ldots + A_m$, $B = B_1 + \ldots + B_m$. Otherwise construct new columns σ^* and τ^* according to the following method and then apply formula (1).

Take $\sigma + \tau = \{A_1 + B_1, A_2 + B_2, \ldots, A_n + B_n\}$ as the pooled sample and solve the equations

$$\sigma^* = \sigma + k(\sigma + \tau). \text{ where } k \text{ is minimal}$$

such that all cell-sizes in σ^* are at least 5, and

$$\tau^* = \tau + \ell(\sigma + \tau) \text{ where } \ell \text{ is minimal}$$

such that all cell sizes in τ^* are at least 5.

Notice that if σ or τ meet the minimum requirement on cell sizes, then k or ℓ will be 0, thereby producing $\sigma^* = \sigma$ or $t^* = \tau$, whatever the case may be.

If $\sigma = \{9,4,51\}$, $\tau = \{3,1,54\}$, the method indicated yields $\sigma^* = \{11.4,5,72\}$, $\tau^* = \{12.6,5,138\}$.

The Chi-squared statistic for σ against τ is 18.62, while the Chi-squared statistic for σ^* against τ^* is 4.72. Notice that pooling cells instead of using the method indicated here would lead to unnecessary complications and problems with uniformity in degrees of freedom.

Furthermore, since the Chi-squared (2.d.f.) statistic 4.72 is significant at the 10% level, we are comfortable in asserting that it is also true that σ versus τ is significant at the 10% level at least. In fact, the effects of regression to the mean can be quite strong, so that, if a difference is significant it is much less likely to represent a false alarm.

§4. The following D = D(G) matrix (example)

	G_1	G_2	G_3	G_4	G_5	G_6(total)
YES	6	146	35	153	28	368
NR	0	19	4	26	1	50
NO	15	170	25	136	29	375

generates a G × 6 Chi-square matric M = M(G):

	G_1	G_2	G_3	G_4	G_5	G_6
G_1	0.00	1.18	5.50	2.56	0.50	1.33
G_2	3.71	0.00	12.90	8.87	4.13	1.64
G_3	3.73	3.06	0.00	0.94	2.52	1.55
G_4	9.85	9.06	4.07	0.00	11.59	3.34
G_5	0.45	1.16	3 33	2.45	0.00	1.12
G_6	10.77	3.88	15.63	7.52	10.89	0.00

At the 5% level, with 2 degrees of freedom, the test statistics should exceed 5.991 in order to be significant.

In the first row, the effect of pooling can be observed in the score G_1 versus G_5, which because of the small cell-sizes present in both distributions lowers the number to 0.50 from what it would have been if we compare {6,15} to {29,29} i.e., 3.857 at 1 degree of freedom for a significance level of 5% approximately. This sacrifice is made so as to maintain the 2 degrees of freedom requirement for all entries. The measurements of overall effects, using a set of questions, will make this sacrifice on our part, less relevant to the results obtained than might otherwise be so.

Knowing that all estimates in the first row are very conservative, we would be justified in considering the M_{13} score 5.50 as probably reflecting significance at the 5% level at least. Nevertheless, we do not adjust the actual score, since it is to be used in determining overall effects.

§5. As can be observed from the example in §4, the matrix $M = M(G)$ can be quite asymmetric, with the M_{ij}-entry not at all equal to the M_{ji}-entry.

Accordingly, since on principle we do not favor group G_i over group G_j, we shall use the matrix $1/2(M + M^T)$ as a measure of effect for a single question.

For the example in §4, if we let $M^S = M(G)^S = (1/2)(M + M^T)$, then we obtain:

	G_1	G_2	G_3	G_4	G_5	G_6
G_1	0.00	2.45	4.61	6.20	0.47	6.05
G_2	2.45	0.00	7.98	8.97	2.64	2.76
G_3	4.61	7.98	0.00	2.51	2.92	8.59
G_4	6.20	8.97	2.51	0.00	7.02	5.43
G_5	0.47	2.64	2.92	7.02	0.00	6.00
G_6	6.05	2.76	8.59	5.43	6.00	0.00

as the resultant matrix.

At a 10% level of significance, we find with some confidence that there is a difference between G_1 and G_3, G_1 and G_4, G_2 and G_3, G_2 and G_4. Whether this difference is due to the "right" causes or the "wrong" causes, is of course not detectable from the data presented here alone.

§6. Suppose now that we wish to construct a measure of "the overall effect" as expressed by the questionnaire's total set of responses. What we shall do, is to weigh the symmetric matrices obtained in §5 according a to a (usual) recipe which assigns a question weight in proportion to its total ability to detect differences.

Thus, if $M_1^s,\ldots,M_q^s$ correspond to q matrices M^s, one for each question, then the new matrix we seek has the form:

$$M^s = w_1M_1^s + \ldots + w_qM_q^s = \sum_{i=1}^{q} w_iM_i^s, \tag{2}$$

with $w_i \geq 0$ and $\Sigma_{i=1}^{q} w_i = 1$.

The matrix M^s is therefore a convex combination of the matrices M_i^s.

If $W_i = \|M_i^s\| = \Sigma_{k,\ell} M_{i,k\ell}^s$, is the sum of all entries of the matrix M_i^s, and if $w_i = W_i/\Sigma_{j=1}^{q} w_j$, then the convexity restrictions are satisfied.

If G_n is the category total, then another method which gives a convex combination, is to take $W_i^* = \Sigma_{\ell} M_{i,n\ell}^s$, and $w_i^* = W_i^*/\Sigma_{j=1}^{q} W_j^*$, with the sum taken over the last row of the matrix only.

Other methods may involve maximizing such functions as $\Sigma_{i,j}(M_{ij}^s)^2 = \Psi(w_1,\ldots,w_q)$ subject to the constraints $w_i \geq 0$, $\Sigma_{i=1}^{q} w_i = 1$. which is then an optimization problem which may be solved in a standard way.

Notice that if a bound is set, such as e.g. 5.991 = B, (5% significance for 2 degrees of freedom), then if $M^S_{ij} \geq B$, it must be true that at least one $M^S_{h,ij} \geq B$ also, since the linear combination is convex. Hence, if a certain level of significance is obtained for a given entry in M^S, then there is at least one particular matrix M^S_i where the same level of significance is also obtained. It is this observation which enables us to consider the matrix M^S as a suitable composite or measure of overall effect.

If instead of the rules described above we select $w_1 = \ldots = w_q = 1/q$, then the mean matrix is obtained as a convex linear combination. However, since it weighs each question equally, it doesn't give those questions which best distinguish among categories the optimum weight. On the other hand, if we select $M = M^S_i$ for that matrix M^S_i with $w_i = \|M^S_i\|$ maximal, then there may be particular entries which are discriminated against because their "best readings" might be present elsewhere. The two first constructions given, i.e., those involving $W_i = \|M^S_i\|$ and W^*_i represent a compromise position which trades off one factor against another.

On the cross-analysis of responses to pairs of non-identical questionnaires.

§1. Questionnaires containing q_1 and q_2 questions are sent to populations stratified into groups $G_1,\ldots,G_n$ and $G_1^*,\ldots,G_n^*$ respectively. The descriptions of the categories G_i and G_i^* are the same for each integer i, $1 \leq i \leq n$. A particular question has responses $r_1,\ldots,r_m$ for the first questionnaire and $r_1^*,\ldots,r_t^*$ for the second questionnaire. Each questionnaire can be analyzed according to methods such as those described in appendices I and II. In this appendix we consider the problem of adjusting the second questionnaire in such a manner as to make a cross-analysis feasible.

§2. If we consider the sequences of questions $Q_1,\ldots,Q_{q_1}$ and $Q_1^*,\ldots,Q_{q_2}^*$, of the two questionnaires, we first determine scalars $u_{ij} \geq 0$ such that $\Sigma_i u_{ij} = 1$ for each j and such that "the contribution of Q_j^* to Q_i is u_{ij}", i.e., as a formal sum we find that:

$$(1) \qquad Q_j^* = \sum_{i=1}^{q_1} u_{ij} Q_i.$$

For example, if $u_{ij} = \delta_{ij}$, the Kronecker delta, $q_1 = q_2$, then $Q_j^* = \delta_{jj} Q_j = Q_j$, i.e., we consider the questions as identical.

If the questions are distinct, but the possible responses are the same, i.e., $m = t$ and $r_i = r_i^*$, for $1 \leq i \leq m$, then equation (1) can easily be translated into the form of display matrices, where $D(G)_i$ is the display matrix for question i w.r.t. G, and $D(G^*)_j$ is the display matrix for question j with respect to G^*. Thus, suppose that U is the $q_1 \times q_2$ matrix with entries u_{ij} and that V is a $q_2 \times q_1$ matrix such that $U \cdot V = Iq_1$, the $q_1 \times q_1$ identity matrix.

If we write:

$$(2) \qquad (Q_1,\ldots,Q_{q_1})\cdot U = (Q_1^*,\ldots,Q_{q_2}^*)$$

instead of (1), then it follows that:

$$(3) \qquad (Q_1,\ldots,Q_{q_1}) = (Q_1^*,\ldots,Q_{q_2}^*)\cdot V,$$

so that formally:

$$(4) \qquad Q_i = \sum_{j=1}^{q_2} V_{ji}\, Q_j^*.$$

Using (4) we construct a display-matrix for the second questionnaire relative to the questions of the first questionnaire by:

$$(5) \qquad D(G)_i = \sum_{j=1}^{q_2} V_{ji} D(G^*)_j,$$

which may then be used in cross-analysis as described below.

§3. If the response sets are not the same, then we have to use a redistribution method as in §2 to obtain the necessary arrangements. Formally, we set

$$(6) \qquad r_j^* = \sum_{i=1}^{m} h_{ij}\, r_i,$$

with $\Sigma_i h_{ij} = 1$ and $h_{ij} \geq 0$. According to (2) if we write

$$(7) \qquad (r_1,\ldots,r_m)\cdot H = (r_1^*,\ldots,r_t^*)$$

and if K is a right inverse for the m × t matrix H, so that $HK = I_m$, then it follows also that:

$$(8) \qquad (r_1,\ldots,r_m) = (r_1^*,\ldots,r_t^*)K.$$

Using equation (8) we may reconstruct $D(G^*)_j$ with entries $A^*_{js\ell}$ corresponding to G_s and answer r^*_ℓ into a new display matric $D(G^*)'_j$ with entries $A^{*'}_{jsi}$ determined by the formula:

(9) $$A^{*'}_{jsi} = \sum_{\ell=1}^{t} A^{*}_{js\ell} K_{\ell i},$$

with K as defined above.

With this accomplished, the conditions m = t and $r_i = r_i^*$ have been met and the method suggested in §2 can then be applied.

§4. Assuming that the methods outlined in §2 and §3 are successful, we are then faced with two formally identical questionnaires.

If we consider corresponding display matrices D(G) and D(G^*) for the first and second questionnaires respectively, then for each group G_i there are distributions σ and τ. We may give goodness-of-fit statistics σ versus τ, τ versus σ, and the corresponding mean value, to describe the change if any of the group G_i's response to the question being considered. Similarly, a most important response difference of proportion z-scores may also be produced as a comparable statistic. From this information 1 × n vectors may then be produced which may be handled according to methods described in appendices I and II.

§5. The fitting problem described resides in the choice of matrices U and H, which need to have right inverses V and K respectively.

If U and H have been determined, take V_0 and K_0 to be some convenient matrices so that UV_0 and HK_0 are right invertible with right inverses V^* and K^* respectively. Thus $UV_0V^* = I$, $HK_0K^* = I$ yields $V_0V^* = V$ and $K_0K^* = K$.

If UV_0 is not right invertible, consider a small perturbation $UV_0 + \varepsilon I$ which produces a right invertible matrix.

If $(UV_0 + \varepsilon I)V^* = I$, then $UV_0V^* = I - \varepsilon V^*$, and for ε small enough, the matrix εV^* is considered "rounding off error" to produce an approximate right inverse $V_0V^* = V$. Similarly, an approximate right inverse $K_0K^* = K$ can be produced for H in this manner. Technically, all problems can be handled provided U and H can be selected in some best possible manner.

§6. If we return to equation (1) and if we replace Q_i by $D(G)_i$, the corresponding known display matrix, then we obtain an expected display matrix:

$$E(G^*)_j = \sum_{i=1}^{q_1} u_{ij}\, D(G)_i. \tag{10}$$

Because of differences in the sizes of the groups G and G^*, it may be necessary to multiply $E(G^*)_j$ by a scalar λ, so that $\lambda E(G^*)_j$ and $D(G^*)_j$ represent the same total sum of entries.

If we write:

$$\Phi(u_{1j},\ldots,u_{q_1j}) = \sum_{k\ell} (\lambda E(G^*)_{j,k\ell} - D(G^*)_{j,k\ell})^2 \tag{11}$$

then to minimize $\Phi(u_{1j},\ldots,u_{q_1j})$ subject to the constraints $u_{1j} + \ldots + u_{q_1j} = 1$, $u_{ij} \geq 0$ is a standard optimization problem which we are usually able to solve without great difficulty.

One way to deal with (11) is to consider all partitions:

$$d_{1j} + \ldots + d_{q_1j} = q_1 \tag{12}$$

of q_1 into non-negative integers, and to evaluate $\Phi(u_{1j},\ldots,u_{q_1j})$, with $u_{ij} = d_{ij}/q_1$ for each partition, selecting the partition which produces a minimal value and the coefficients u_{ij} accordingly. For a small number of questions q_1, this method is fast and simple to apply.

The matrix H can be determined in essentially the same way, should it be necessary to do so.

§7. If we select the matrix U in the manner described in §6, then we have reconstructed the questionnaires in such a way as to minimize any differences which may exist between them. Thus, if cross-analysis afterwards reveals the existence of significant differences in prevailing patterns, we can be

certain that any other arrangement or re-arrangement would display differences of at least that magnitude.

Since the method described in §6 is a rather mechanical way of doing things, it may in fact be reasonable to actually compare the questions and assign the values u_{ij} subjectively. What should be realized is that if this is done, then differences noted will be at least as large as those noted when the method of §6 is applied to the data.

On the use of odds-ratios in the analysis of accident data.

§1. Suppose that groups $G_1,G_2,\ldots,G_n$ have experienced accidents of types $T_1,\ldots,T_m$, with the number of accidents of type T_i experienced by group G_j, N_{ij}, displayed as the $(i,j)^{th}$ entry in a data matrix which can also serve as a graph of a discrete joint-distribution. As an $m \times n$ contingency table, the inclusion of the margins then produces an $(m+1) \times (n+1)$ array denoted by N^*. Thus, e.g., $N^*_{m+1,j}$ denotes the total number of accidents experienced by group G_j, while $N^*_{i,n+1}$ denotes the total number of accidents of type T_i experienced by the group G, where G is the union of $G_1,G_2,\ldots,G_n$, the groups G_i being disjoint.

§2. If a subset $S_1 = \{i_1,\ldots,i_k\}$ of $\{1,\ldots,m\}$ is considered to be a given factor, i.e., if $T_{i_1} + \ldots + T_{i_k} = T_{S_1}$ denotes a "new" type of accident, then we may collect the other data into another group S_1^*, with $T^*_{S_1}$ denoting the variable not T_{S_1}, i.e., the complementary factor.

Similarly, a subset $S_2 = \{j_1,\ldots,j_\ell\}$ of $\{1,\ldots,n\}$ produces groups $G_{S_2} = G_{j_1} \cup \ldots \cup G_{j_\ell}$ and its complement $G^*_{S_2}$. Using these partitions we may reduce the original data matrices N and N^* to 2×2 and 3×3 layouts as follows:

	G_{S_2}	$G^*_{S_2}$	G
T_{S_1}	A	B	A + B
$T^*_{S_1}$	C	D	C + D
T	A + C	B + D	A + B + C + D

with:

$$A = \sum_{i \in S_1, j \in S_2} N_{ij}, \quad B = \sum_{i \in S_1, j \notin S_2} N_{ij}$$

$$C = \sum_{i \notin S_1, j \in S_2} N_{ij}, \quad D = \sum_{i \in S_1, j \notin S_2} N_{ij}$$

$$A + B = \sum_{i \in S_1} N^*_{i,n+1}, \quad C + D = \sum_{i \notin S_1} N^*_{i,n+1}$$

$$A + C = \sum_{j \in S_2} N^*_{m+1,j}, \quad B + D = \sum_{j \notin S_2} N^*_{m+1,j}$$

$$A + B + C + D = N^*_{m+1,n+1}$$

§3. Given that an accident took place, the odds that the accident was of type T_{S_1} is A/C for the group G_{S_2} and B/D for the group $G^*_{S_2}$. The relative odds, or the odds-ratio is therefore the quotient:

(1) $$(A/C)/(B/D) = AD/BC.$$

The odds-ratio is a very stable measure of relative risk as the following argument should make clear.

Suppose G_{S_2} corresponds to a population P_{S_2} and $G^*_{S_2}$ corresponds to a population $P^*_{S_2}$, with $P = P_{S_2} \cup P^*_{S_2}$ denoting the entire population. Suppose that a sample of N_1 persons is selected at random from P_{S_1} and a sample of N_2 persons is selected from P_{S_2}.

Suppose that F_i persons in the sample of N_i persons had an accident. Then, the frequencies of accidents are $f_i = (F_i/N_i)$ for the two groups. Now, given that the proportions in the contingency table constructed above, we expect that for the sample we have a contingency table which is approximately:

	P_{S_2}	$P^*_{S_2}$	P
T_{S_1}	$F_1(\frac{A}{A+C})$	$F_2(\frac{B}{B+D})$	*
$T^*_{S_1}$	$F_1(\frac{C}{A+C})$	$F_2(\frac{D}{B+D})$	*
T	F_1	F_2	$F_1 + F_2$

for which we compute the odds-ratio to be:

$$F_1F_2(\frac{AD}{(A+C)(B+D)})/F_1F_2(\frac{BC}{(A+C)(B+D)}) = AD/BC.$$

Similarly, if we use f_i instead of F_i, then for the contingency table:

	P_{S_2}	$P^*_{S_2}$	P
T_{S_1}	$f_1(\frac{A}{A+C})$	$f_2(\frac{B}{B+D})$	*
$T^*_{S_1}$	$f_1(\frac{C}{A+C})$	$f_2(\frac{D}{B+D})$	*
T	f_1	f_2	$f_1 + f_2$

the odds-ratio still equals AD/BC.

Other measures do not possess this stability and they are accordingly much more sensitive to sampling procedures and interpretations. We note that under reasonable circumstances the odds-ratio permits us to select G as representative of P without as much fear of the introduction of bias as other procedures might warrant.

§4. Given the data lay-out as in the first contingency table, the Mantel-Haenszel Chi-square statistic is:

(2) $$\chi^2_1 = \frac{(A+B+C+D-1)(AD-BC)^2}{(A+C)(B+D)(A+B)(C+D)},$$

which is used as an approximation to the exact value:

$$(3)\quad \Pr((T_{S_1} \times G_{S_2}) \geq A \mid H_0\colon AD/BC = 1) = \left(\sum_{j=A}^{A+B} \binom{A+C}{j}\binom{B+D}{A+B-j}\right) \Big/ \binom{A+B+C+D}{A+B}.$$

If the value of either term is sufficiently large, then H_0 is rejected in favor of an alternative hypothesis H_A: $AD/BC > 1$.

Notice that by permuting columns or permuting rows (but not both), the resulting data layout will have odds-ratio BC/AD, with the same χ_1^2 which will then measure the alternative hypothesis H_A:$BC/AD > 1$ (or $AD/BC < 1$) versus H_0: $BC/AD = 1$ (or $AD/BC = 1$), so that it is easy to replace one test by another.

For a more detailed discussion, see for example Kleinbaum-Kupper-Morgenstern, Epidemiologic Research, Ch. 15: Statistical inferences about effect measures: simple analysis.

Although the Mantel-Haenszel works relatively well for even smaller cell sizes, it helps if $C,D \geq 5$ as usual. In case this is not so, exact tests are then easily performed since the numbers involved are small.

§5. If we consider the contingency table observed as a sample drawn from a population then, modulo some restrictions which are not too rigid for odds-ratios as indicated in §3, the natural logarithms of the (sample) odds-ratios are normally distributed. Thus, we can also provide a statistic which indicates the percentrage of the odds-ratio distribution to the left of 1. This statistic varies from 0 to 1 and provides a "protection rating". For example a value in excess of .95 would indicate that there is significant protection, with the odds-ratio itself indicating the most likely amount of protection.

The formula for this rating is given approximately by $\Phi^{-1}(Z)$, where the Z-score is given by the formula:

$$(4) \qquad \frac{(\ell n\, B + \ell n\, C - \ell n\, A - \ell n\, D)}{\sqrt{\frac{1}{A} + \frac{1}{B} + \frac{1}{C} + \frac{1}{D}}},$$

with A,B,C,D as given in the first contingency table.

Notice that the Z-score, unlike the odds-ratio, does depend on the entries A,B,C and D.

For example, a data lay-out:

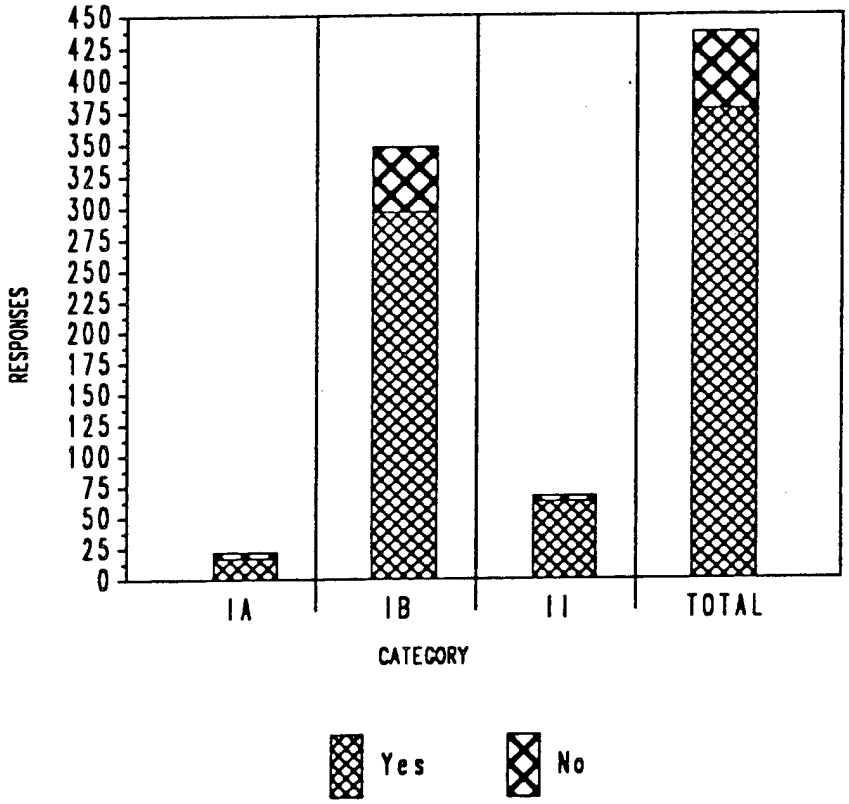
	G_{S_2}	$G^*_{S_2}$	G
T_{S_1}	8	2	10
$T^*_{S_1}$	30	20	50
T	38	22	60

has an odds-ratio of (8)(20)/(30)(2) = 2.667 and a protection-rating of $\Phi^{-1}(-1.1653)$ = .1230 approximately. The conclusion would then be that the probability is .1230 that being in group G_{S_2} is safer with respect to accidents of type T_{S_1} than it is to be in $G^*_{S_2}$, in other words, $G^*_{S_2}$ is close to being significantly safer than G_{S_2} with respect to this factor.

AVIATION 82-83

Question 1: Duty Status

CATEGORY	IA	IB	I I	TOTAL
YES	17	296	63	376
NO	5	51	4	60
TOTAL	22	347	67	436



CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	1.13	11.00**	1.49
IB	12.74**	0.00	47.08**	0.26
II	10.71**	4.07*	0.00	3.43
TOTAL	19.96**	0.30	47.15**	0.00

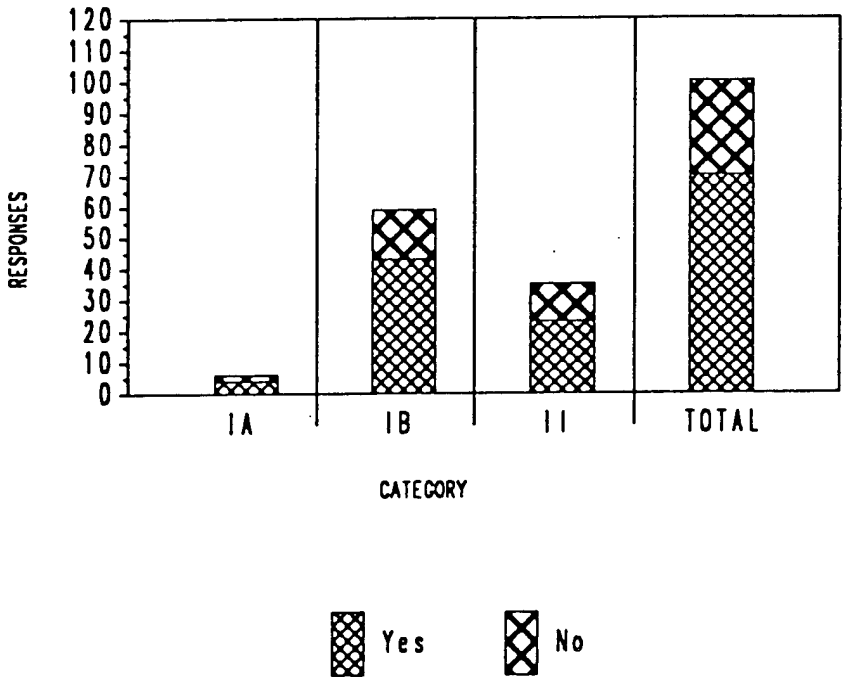
* $p \leq 0.05$

** $p \leq 0.01$

AVIATION 86-87

Question 1: Duty Status

CATEGORY	IA	IB	I I	TOTAL
YES	2	43	23	70
NO	2	16	12	30
TOTAL	6	59	35	100



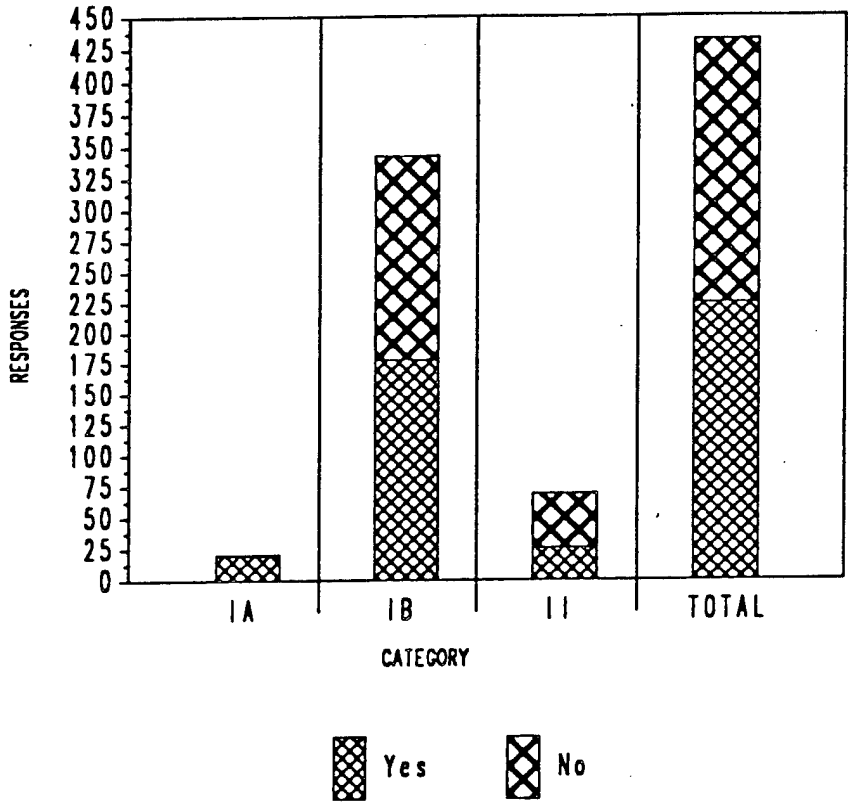
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.06	0.00	0.01
IB	0.19	0.00	1.35	0.23
II	0.00	0.91	0.00	0.31
TOTAL	0.09	0.42	0.82	0.00

AVIATION 82-83

Question 2: Collateral Investigation

CATEGORY	IA	IB	I I	TOTAL
YES	20	178	26	224
NO	1	164	43	208
TOTAL	21	342	69	432



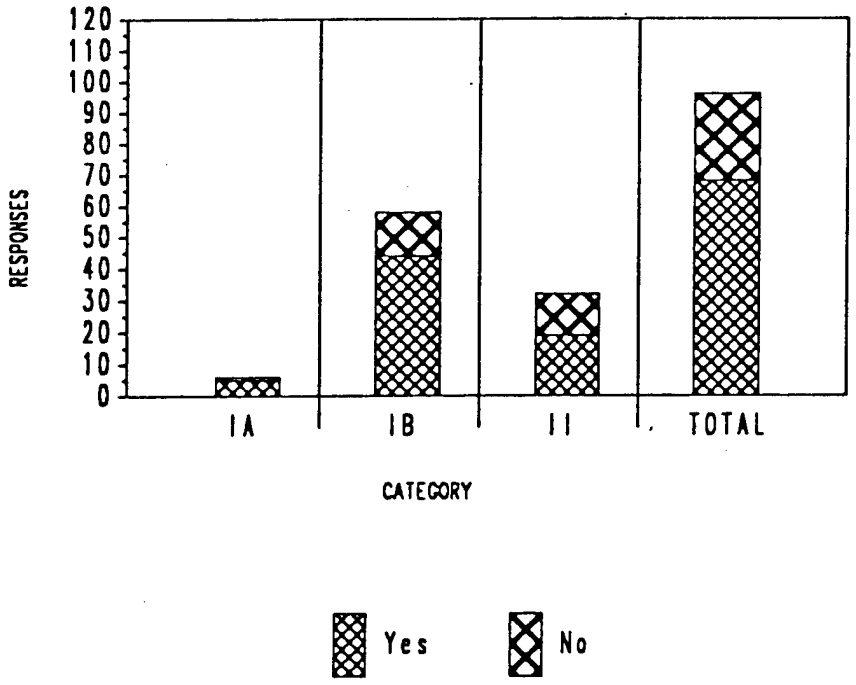
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	11.60**	25.37**	11.64**
IB	238.04**	0.00	30.06**	0.01
II	99.22**	5.71*	0.00	5.55*
TOTAL	301.96**	0.01	36.94**	0.00

AVIATION 86-87

Question 2: Collateral Investigation

CATEGORY	IA	IB	II	TOTAL
YES	5	44	19	68
NO	1	14	13	28
TOTAL	6	58	32	88



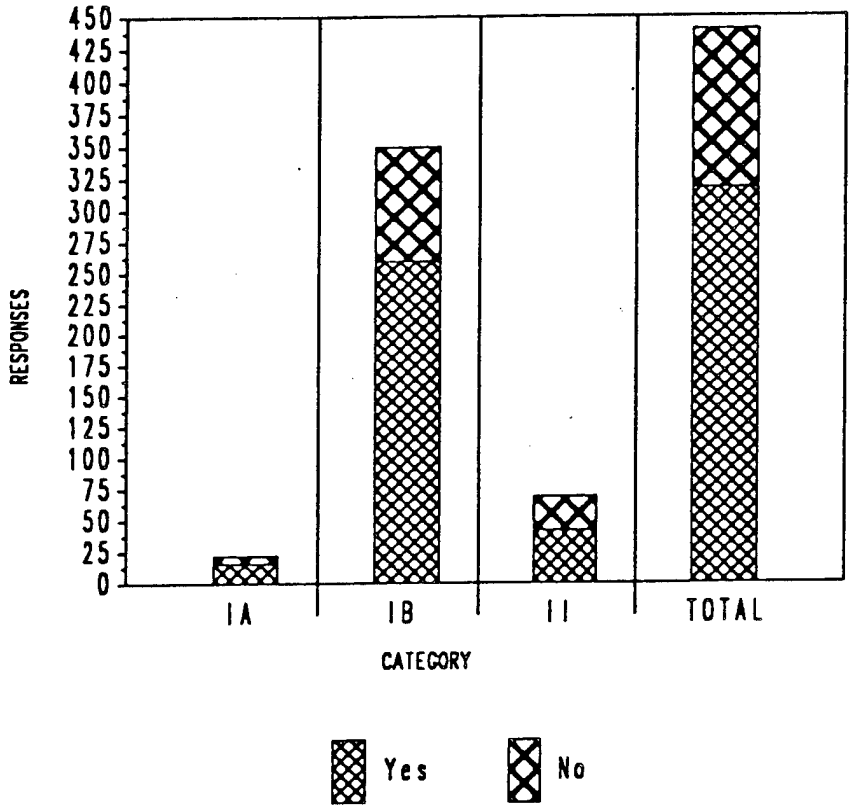
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.08	0.84	0.18
IB	0.21	0.00	6.54*	0.71
II	1.84	4.75*	0.00	2.03
TOTAL	0.93	1.33	5.23*	0.00

AVIATION 82-83

Question 3: Training

CATEGORY	IA	IB	I I	TOTAL
YES	16	259	42	317
NO	6	90	27	123
TOTAL	22	349	69	440



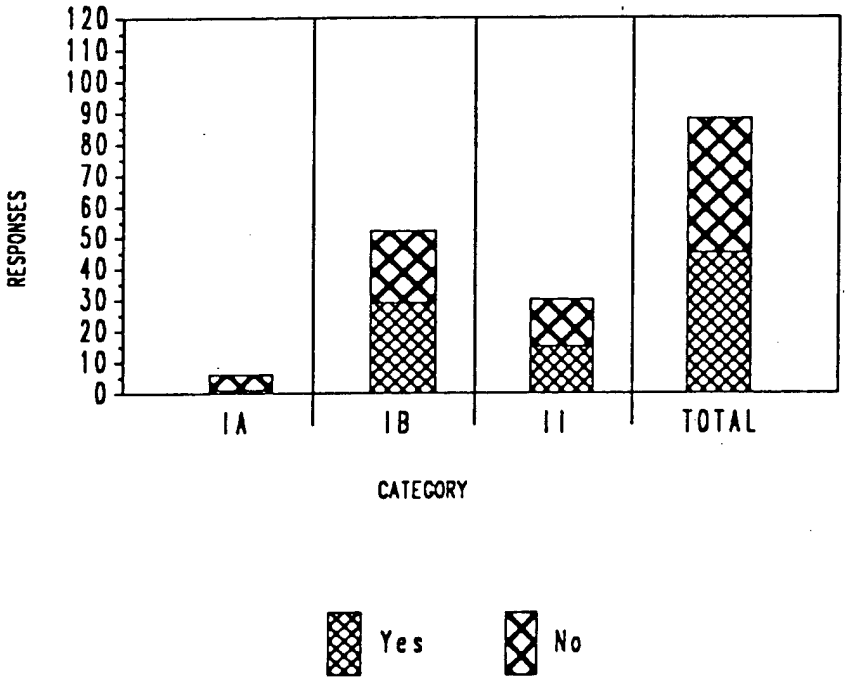
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.03	1.30	0.01
IB	0.39	0.00	26.08**	0.81
II	4.89*	6.42*	0.00	4.28*
TOTAL	0.10	1.08	23.07**	0.00

AVATION 86-87

Question 3: Training

CATEGORY	IA	IB	I I	TOTAL
YES	1	29	15	45
NO	5	23	15	43
TOTAL	6	52	30	88



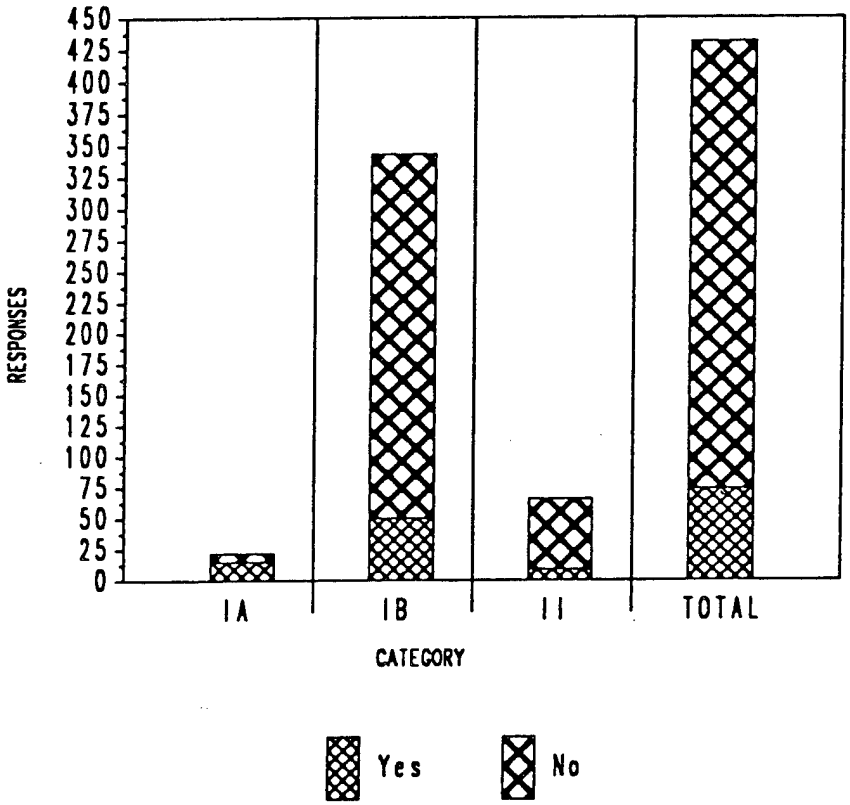
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	2.09	1.67	1.43
IB	8.42**	0.00	0.69	0.45
II	3.75	0.40	0.00	0.02
TOTAL	9.70**	0.77	0.05	0.00

AVIATION 82-83

Question 4: Unfavorable Personnel Actions

CATEGORY	IA	IB	I I	TOTAL
YES	15	50	9	74
NO	7	293	57	357
TOTAL	22	343	66	431



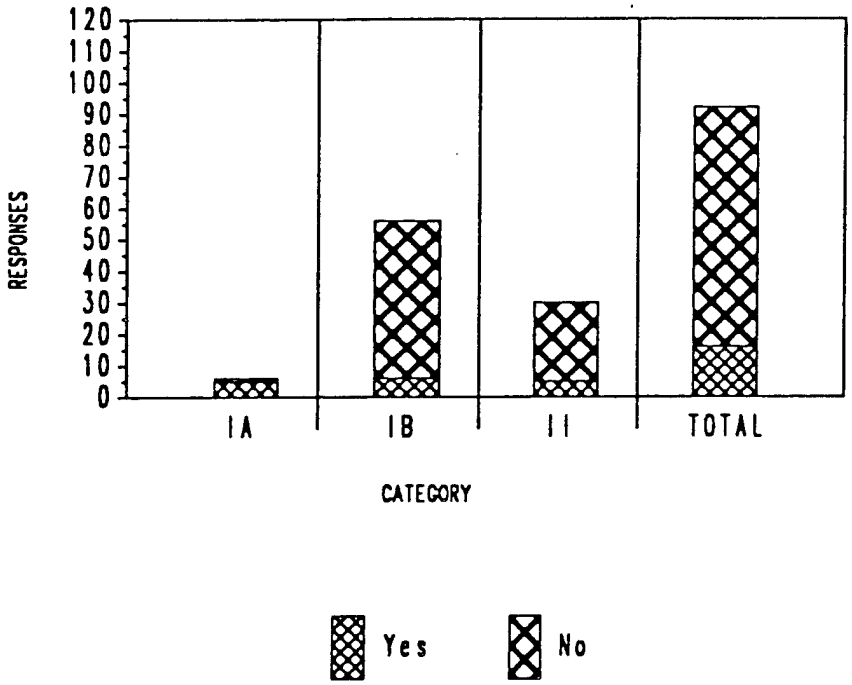
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	50.77**	55.58**	40.26**
IB	454.31**	0.00	0.26	1.62
II	90.51**	0.05	0.00	0.58
TOTAL	516.99**	2.33	4.57*	0.00

AVAITION 86-87

Question 4: Unfavorable Personnel Actions

CATEGORY	IA	IB	I I	TOTAL
YES	5	6	5	16
NO	1	50	25	76
TOTAL	6	56	30	92



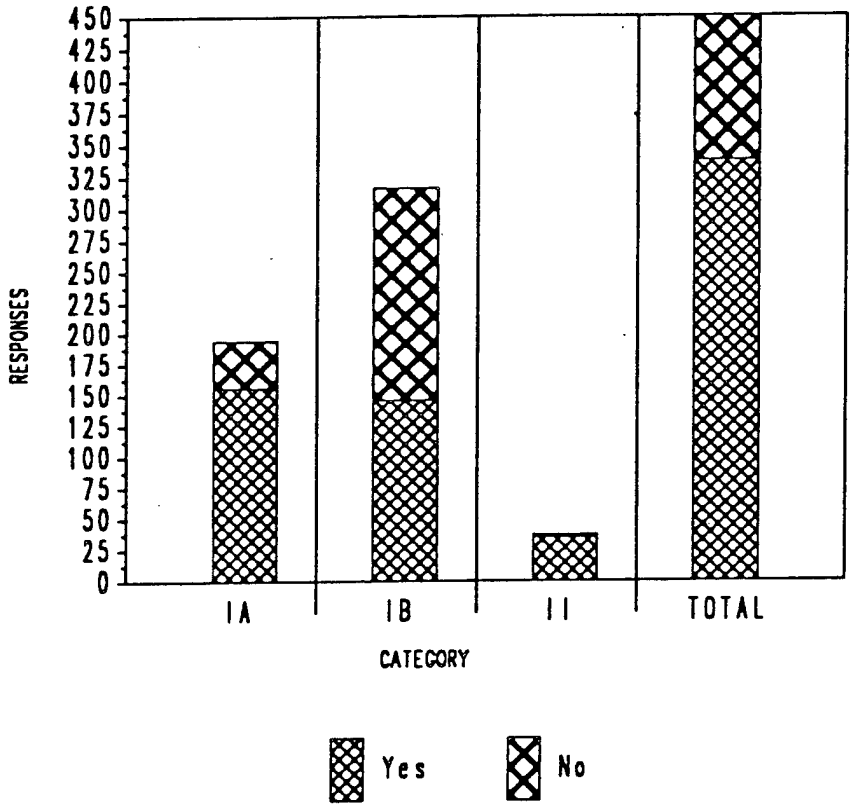
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	21.25**	13.29**	10.87**
IB	42.18**	0.00	1.43	1.74
II	19.55**	1.11	0.00	0.01
TOTAL	52.33**	4.29*	0.03	0.00

AVIATION 82-83

Question 5: Favorable Personnel Actions

CATEGORY	IA	IB	I I	TOTAL
YES	156	146	35	337
NO	38	170	2	210
TOTAL	194	316	37	547



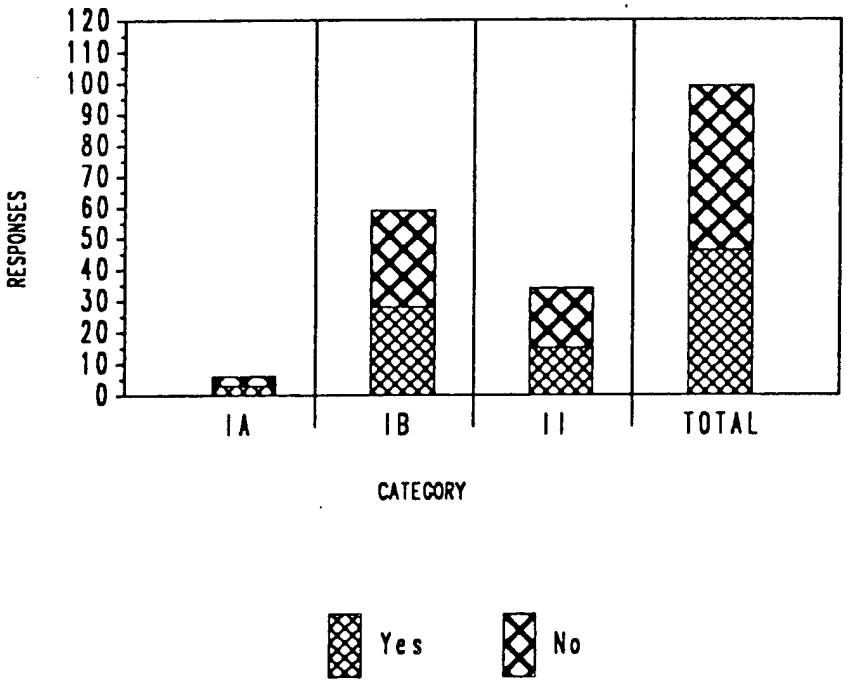
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	91.34**	25.03**	29.00**
IB	234.79**	0.00	549.69**	31.71**
II	3.72	30.94**	0.00	14.31**
TOTAL	122.79**	52.23**	416.26**	0.00

AVAITION 86-87

Question 5: Favorable Personnel Actions

CATEGORY	IA	IB	I I	TOTAL
YES	3	28	15	46
NO	3	31	19	53
TOTAL	6	59	34	99



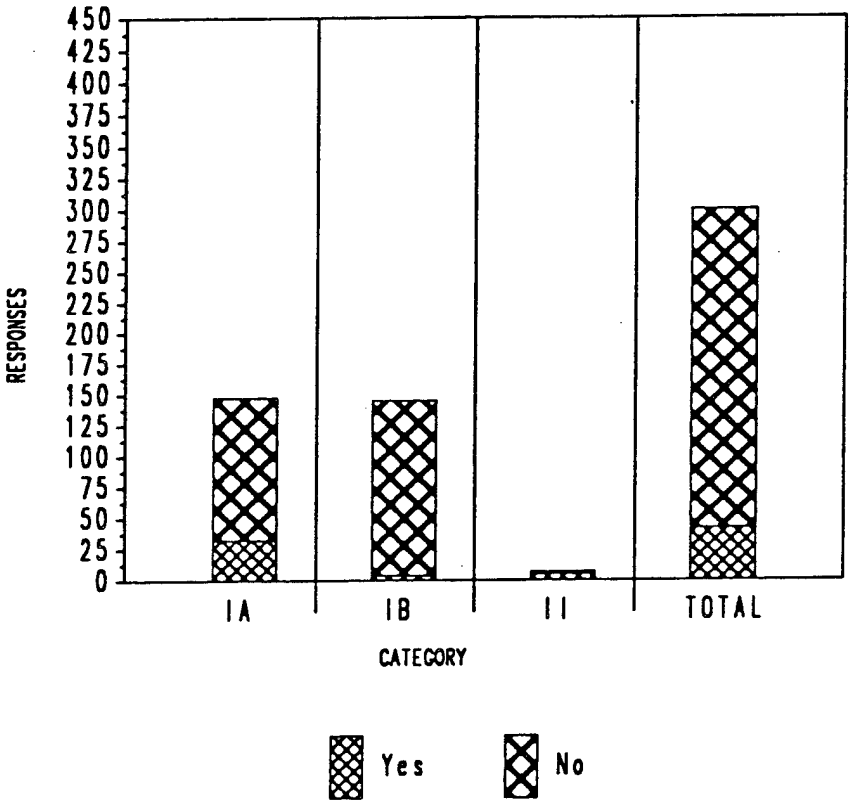
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.02	0.08	0.03
IB	0.15	0.00	0.27	0.02
II	0.47	0.15	0.00	0.08
TOTAL	0.49	0.04	0.22	0.00

AVIATION 82-83

Question 6: Other Accidents

CATEGORY	IA	IB	I I	TOTAL
YES	33	4	5	42
NO	115	141	2	258
TOTAL	148	145	7	300



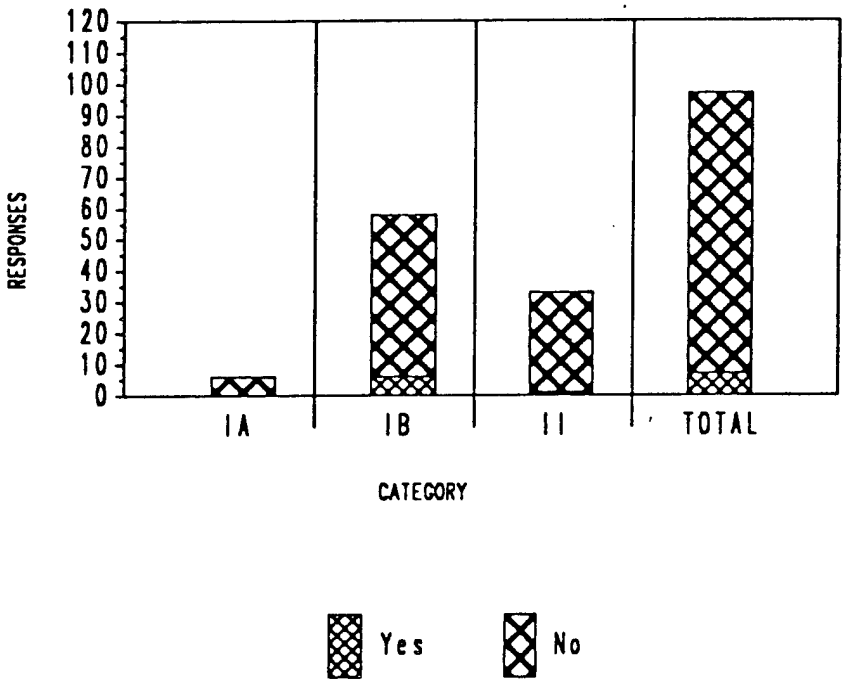
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	210.62**	61.65**	8.46**
IB	31.95**	0.00	134.61**	15.22**
II	6.54*	88.12**	0.00	13.03**
TOTAL	11.92**	141.32**	179.01**	0.00

AVAITION 86-87

Question 6: Other Accidents

CATEGORY	IA	IB	I I	TOTAL
YES	0	6	1	7
NO	6	52	32	90
TOTAL	6	58	33	97



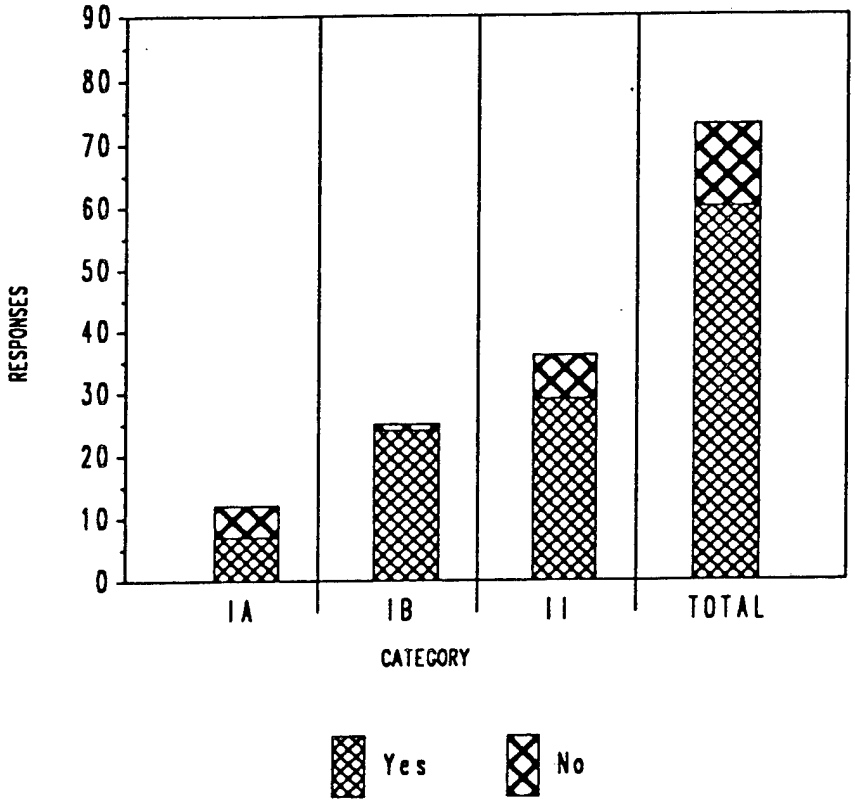
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.24	0.02	0.10
IB	0.28	0.00	2.09	0.85
II	0.02	1.83	0.00	0.65
TOTAL	0.14	1.02	0.90	0.00

GROUND 82-83

Question 1: Duty Status

CATEGORY	IA	IB	I I	TOTAL
YES	7	24	29	60
NO	5	1	7	13
TOTAL	12	25	36	73



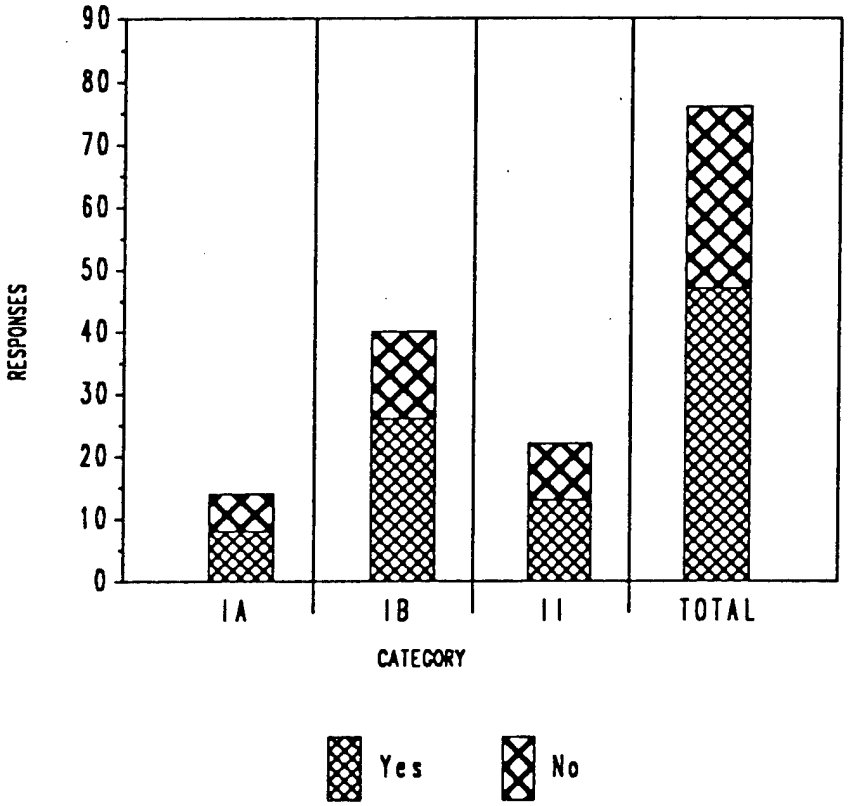
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	13.23**	3.78	4.67*
IB	20.40**	0.00	3.86*	2.54
II	7.31**	4.78*	0.00	0.07
TOTAL	17.10**	5.99*	0.12	0.00

GROUND 86-87

Question 1: Duty Status

CATEGORY	IA	IB	I I	TOTAL
YES	8	26	13	47
NO	6	14	9	29
TOTAL	14	40	22	76



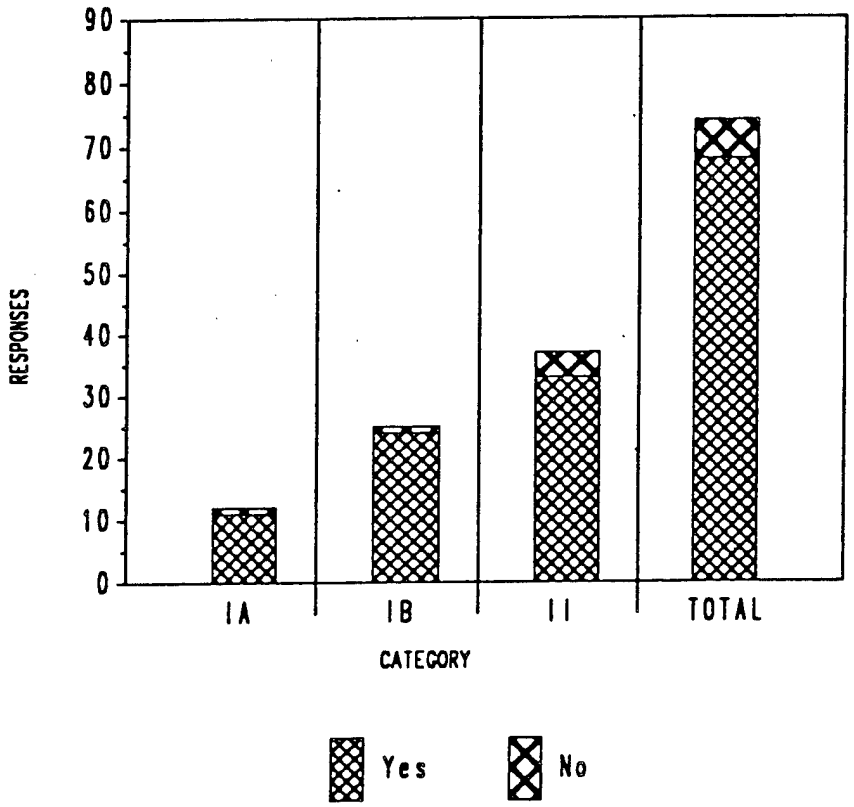
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.38	0.02	0.13
IB	1.01	0.00	0.58	0.17
II	0.03	0.34	0.00	0.07
TOTAL	0.69	0.33	0.24	0.00

GROUND 82-83

Question 2: Collateral Investigation

CATEGORY	IA	IB	I I	TOTAL
YES	11	24	33	68
NO	1	1	4	6
TOTAL	12	25	37	74



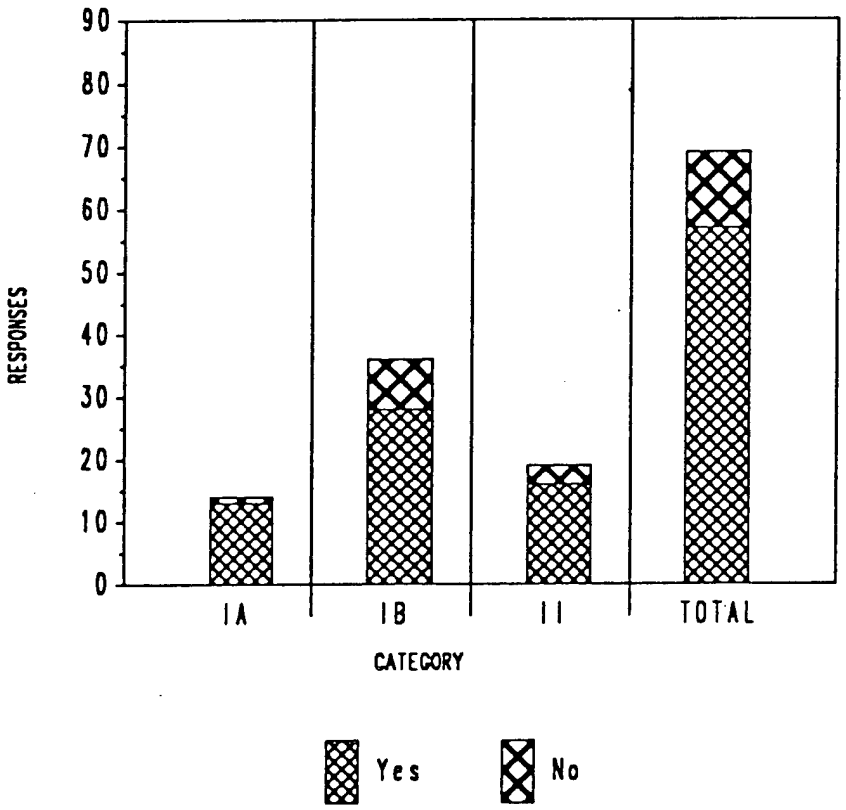
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.10	0.06	0.00
IB	0.11	0.00	1.31	0.43
II	0.05	1.00	0.00	0.36
TOTAL	0.00	0.50	0.56	0.00

GROUND 86-87

Question 2: Collateral Investigation

CATEGORY	IA	IB	I I	TOTAL
YES	13	28	16	57
NO	1	8	3	12
TOTAL	14	36	19	69



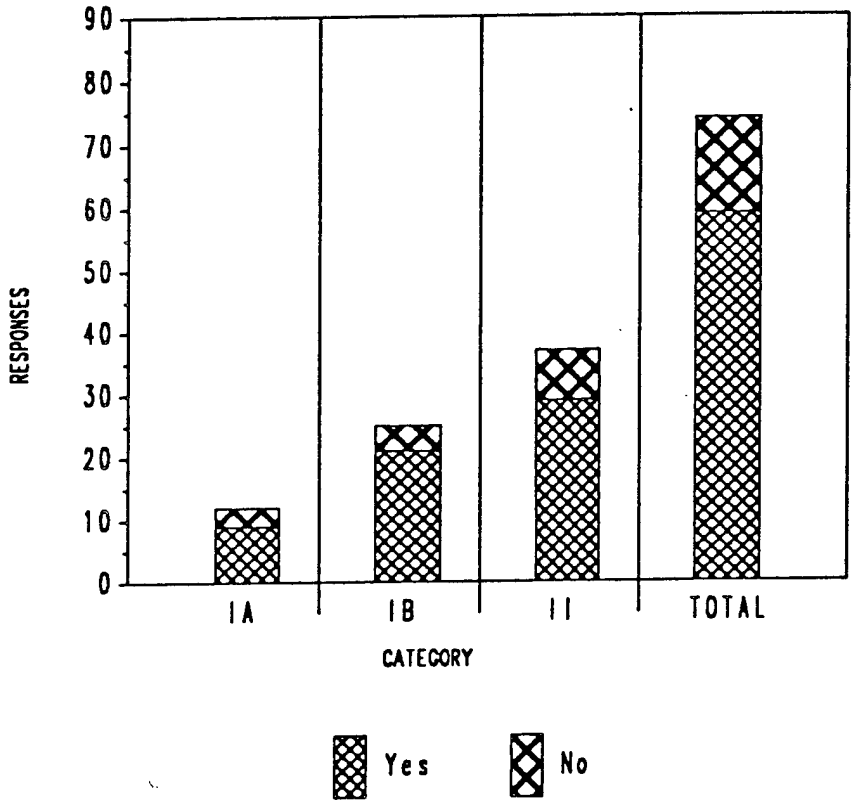
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	1.49	0.94	0.62
IB	2.14	0.00	1.12	0.58
II	0.53	0.45	0.00	0.03
TOTAL	1.41	0.93	0.13	0.00

GROUND 82-83

Question 3: Training

CATEGORY	IA	IB	I I	TOTAL
YES	9	21	29	59
NO	3	4	8	15
TOTAL	12	25	37	74



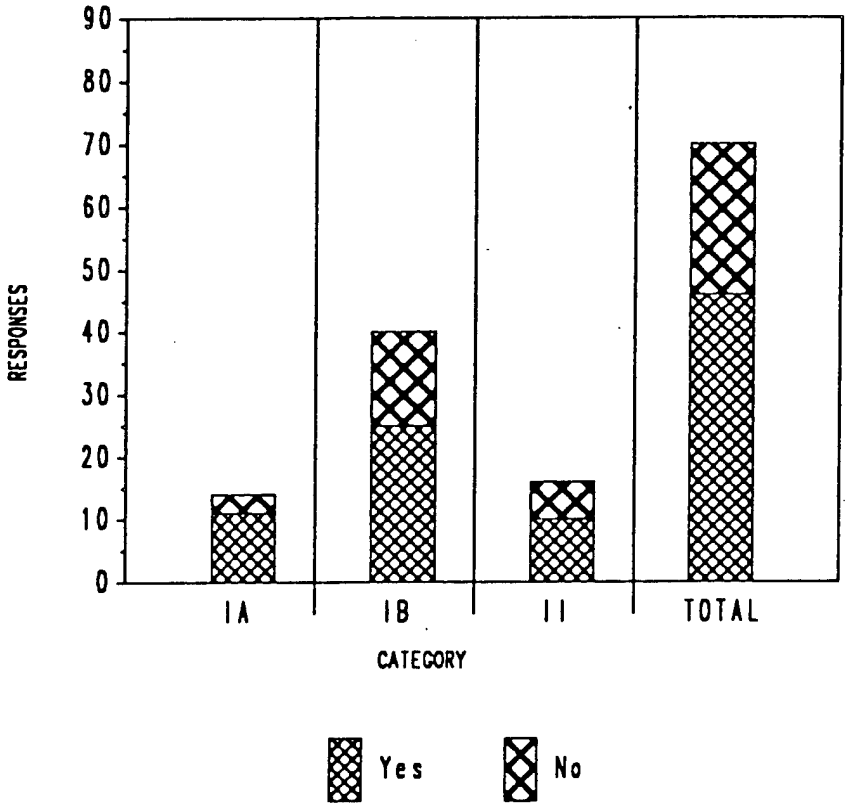
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.72	0.08	0.17
IB	1.08	0.00	0.47	0.28
II	0.23	0.87	0.00	0.04
TOTAL	0.88	1.00	0.08	0.00

GROUND 86-87

Question 3: Training

CATEGORY	IA	IB	II	TOTAL
YES	11	25	10	46
NO	3	15	6	24
TOTAL	14	40	16	70



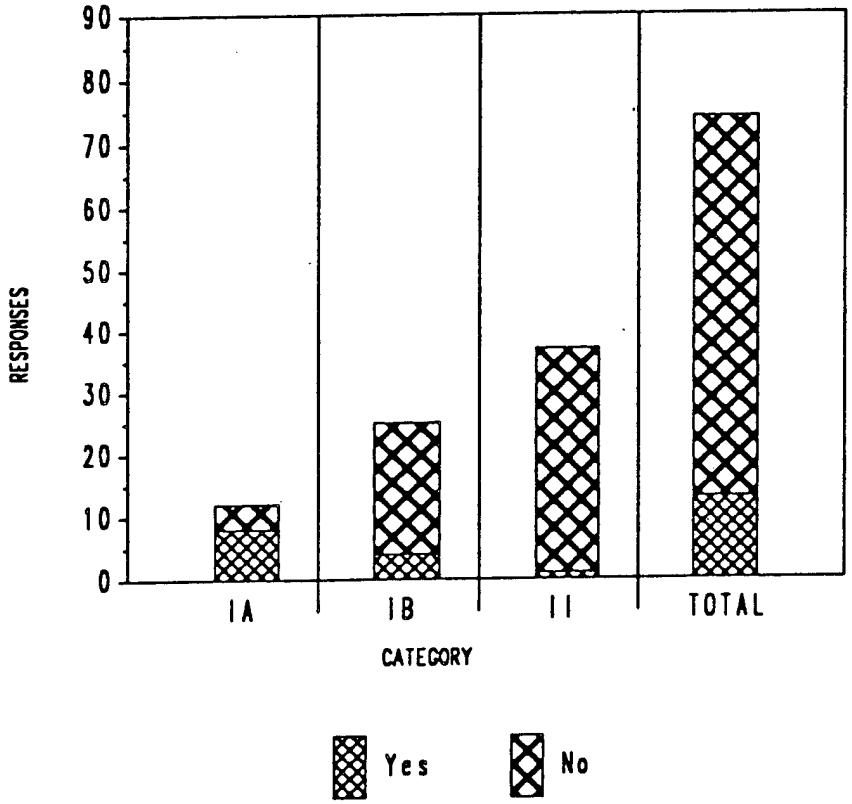
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	1.54	1.54	1.03
IB	6.14*	0.00	0.00	0.18
II	2.45	0.00	0.00	0.07
TOTAL	6.87**	0.31	0.31	0.00

GROUND 82-83

Question 4: Unfavorable Personnel Actions

CATEGORY	IA	IB	I I	TOTAL
YES	8	4	1	13
NO	4	21	36	61
TOTAL	12	25	37	74



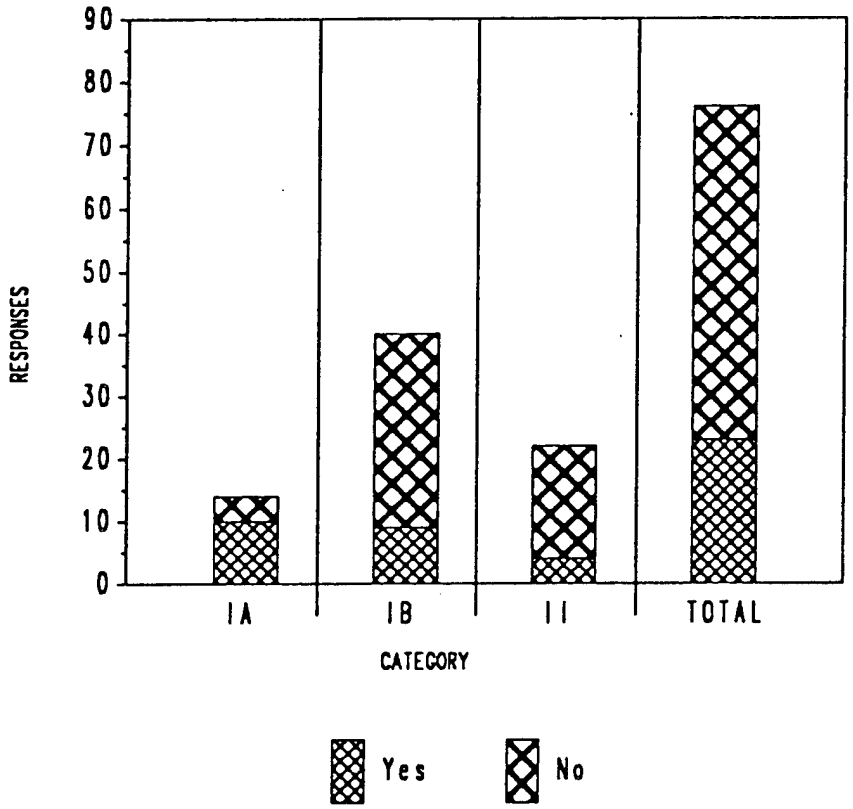
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	22.92**	52.15**	19.98**
IB	28.88**	0.00	4.81*	0.04
II	89.47**	6.74**	0.00	5.03*
TOTAL	80.28**	0.14	11.62**	0.00

GROUND 86-87

Question 4: Unfavorable Personnel Actions

CATEGORY	IA	IB	I I	TOTAL
YES	10	9	4	23
NO	4	31	18	53
TOTAL	14	40	22	76



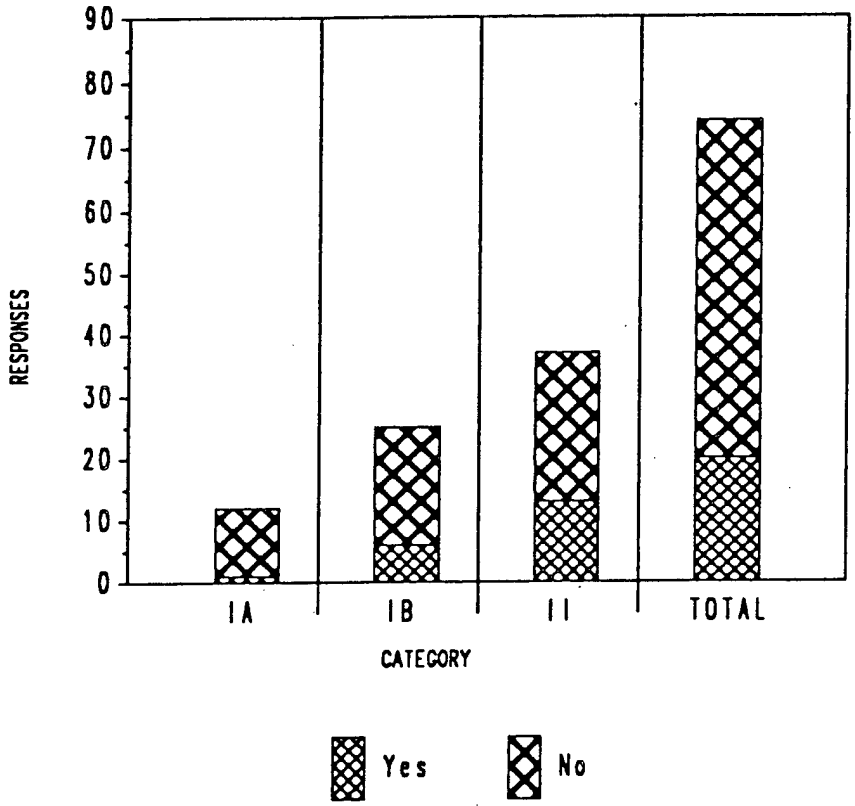
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	19.22**	26.68**	11.24**
IB	46.92**	0.00	0.50	1.14
II	30.56**	0.24	0.00	1.52
TOTAL	63.11**	2.63	7.46**	0.00

GROUND 82-83

Question 5: Favorable Personnel Actions

CATEGORY	IA	IB	I I	TOTAL
YES	1	6	13	20
NO	11	19	24	54
TOTAL	12	25	37	74



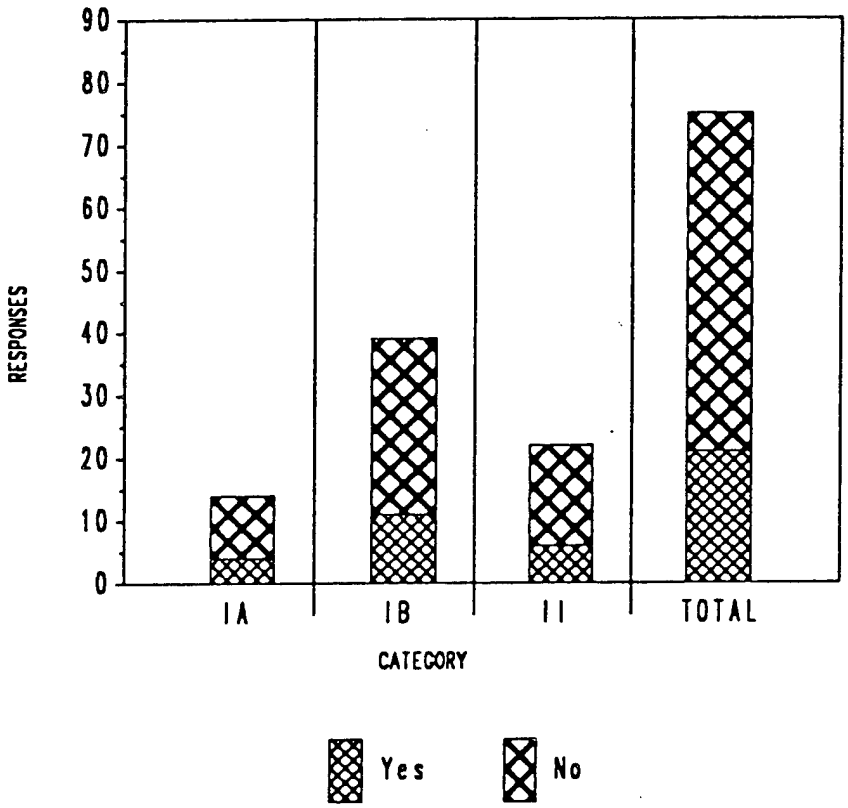
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	1.44	2.89	1.27
IB	1.55	0.00	1.36	0.12
II	6.03*	2.52	0.00	1.23
TOTAL	4.51*	0.37	2.13	0.00

GROUND 86-87

Question 5: Favorable Personnel Actions

CATEGORY	IA	IB	I I	TOTAL
YES	4	11	6	21
NO	10	28	16	54
TOTAL	14	39	22	75



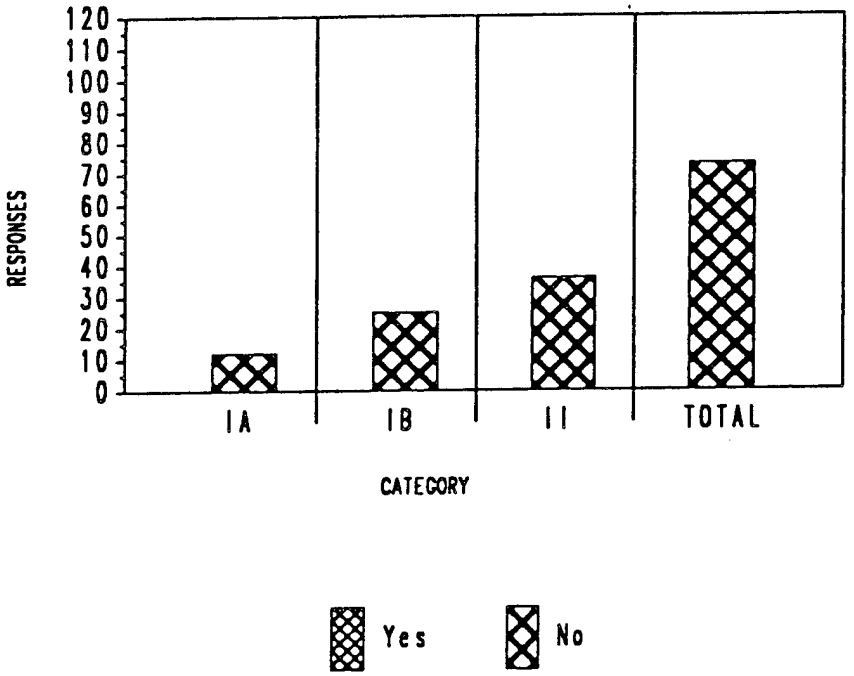
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.00	0.01	0.00
IB	0.00	0.00	0.02	0.00
II	0.02	0.01	0.00	0.01
TOTAL	0.01	0.00	0.02	0.00

GROUND 82-83

Question 6: Other Accidents

CATEGORY	IA	IB	I I	TOTAL
YES	0	0	0	0
NO	12	25	36	73
TOTAL	12	25	36	73



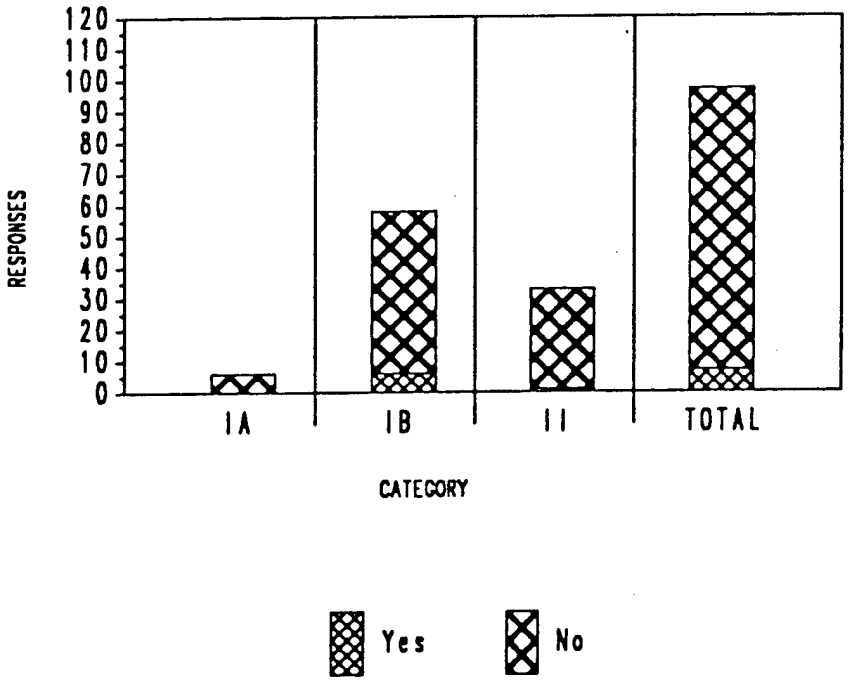
CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.00	0.05	0.02
IB	0.00	0.00	0.13	0.05
II	0.05	0.13	0.00	0.09
TOTAL	0.02	0.05	0.09	0.00

GROUND 86-87

Question 6: Other Accidents

CATEGORY	IA	IB	I I	TOTAL
YES	0	6	1	7
NO	6	52	32	90
TOTAL	6	58	33	97



CHI - SQUARE MATRIX

	IA	IB	II	TOTAL
IA	0.00	0.24	0.00	0.08
IB	0.23	0.00	0.44	0.33
II	0.00	0.44	0.00	0.17
TOTAL	0.18	0.34	0.17	0.00

CROSS ANALYSIS AVIATION (82-83 vs 86-87)

CHI - SQUARE CROSS ANALYSIS

QUESTION #1

0.0	1783.33	0.0	14800.00
6605.26	0.0	3387.41	13.04
0.0	347.25	0.0	1006.45
22077.78	-28.57	5650.00	0.0

QUESTION #2

0.0	14400.00	2920.24	6366.67
113252.38	0.0	359.63	-98.59
5292.39	20.21	0.0	173.40
32368.82	-99.25	606.31	0.0

QUESTION #3

0.0	-98.56	-22.16	-99.30
-95.37	0.0	3679.71	80.00
30.40	1505.00	0.0	21300.00
-98.97	40.26	46040.00	0.0

QUESTION #4

0.0	138.92	318.21	270.38
977.07	0.0	-81.82	-6.90
362.97	-95.50	0.0	5700.00
887.94	-45.69	15133.33	0.0

QUESTION #5

0.0	456600.00	31187.50	96566.67
156426.67	0.0	203488.89	158450.00
691.49	20526.67	0.0	17787.50
24959.18	130475.00	189109.09	0.0

QUESTION #6

0.0	87658.33	308150.00	8360.00
11310.71	0.0	6340.67	1690.59
32600.00	4715.30	0.0	1904.62
8414.29	13754.90	19790.00	0.0

CROSS ANALYSIS GROUND (82-83 vs 86-87)

CHI - SQUARE CROSS ANALYSIS

QUESTION #1

0.0	3381.58	18800.00	3492.31
1919.80	0.0	565.52	1394.12
24266.67	1305.88	0.0	0.0
2378.26	1715.15	-50.00	0.0

QUESTION #2

0.0	-93.29	-93.62	-100.00
-94.86	0.0	16.96	-25.86
-90.57	122.22	0.0	1100.00
-100.00	-46.24	330.77	0.0

QUESTION #3

0.0	-53.25	-94.81	-83.50
-82.41	0.0	0.0	55.56
-90.61	0.0	0.0	-42.86
-87.19	222.58	-74.19	0.0

QUESTION #4

0.0	19.25	95.46	77.76
-38.45	0.0	862.00	-96.49
192.77	2708.33	0.0	230.92
27.21	-94.68	55.76	0.0

QUESTION #5

0.0	0.0	28800.00	0.0
0.0	0.0	6700.00	0.0
30050.00	25100.00	0.0	12200.00
45000.00	0.0	10550.00	0.0

QUESTION #6

0.0	-100.00	0.0	-75.00
-100.00	0.0	-70.45	-84.85
0.0	-70.45	0.0	-47.06
-75.00	-85.29	-47.06	0.0

ODDS-RATIO ANALYSIS AVIATION 82-83

	IA vs IB+II	IB vs IA+II	II vs IA+IB
THE ODDS RATIOS FOR QUESTION # 1			
	0.52	0.65	2.82
THE CONFIDENCE INTERVALS FOR QUESTION # 1			
	1.47	2.84	17.08
	0.18	0.15	0.46
THE MANTEL- HAENZEL FOR QUESTION # 1			
	1.64	1.25	4.04*
THE ODDS RATIOS FOR QUESTION # 2			
	20.29**	1.04	0.50
THE CONFIDENCE INTERVALS FOR QUESTION # 2			
	304.02	30.41	25.78
	1.35	0.04	0.01
THE MANTEL- HAENZEL FOR QUESTION # 2			
	16.60**	0.02	6.59*
THE ODDS RATIOS FOR QUESTION # 3			
	1.04	1.64	0.54
THE CONFIDENCE INTERVALS FOR QUESTION # 3			
	59.64	105.59	39.13
	0.02	0.03	0.01
THE MANTEL- HAENZEL FOR QUESTION # 3			
	0.01	3.92	5.06*
THE ODDS RATIOS FOR QUESTION # 4			
	12.71**	0.46	0.73
THE CONFIDENCE INTERVALS FOR QUESTION # 4			
	1015.81	40.23	71.11
	0.16	0.01	0.01
THE MANTEL- HAENZEL FOR QUESTION # 4			
	42.32**	7.92**	0.68
THE ODDS RATIOS FOR QUESTION # 5			
	3.90*	0.18	12.05**
THE CONFIDENCE INTERVALS FOR QUESTION # 5			
	387.96	18.23	1244.84
	0.04	0.00	0.12
THE MANTEL- HAENZEL FOR QUESTION # 5			
	394.19**	444.57**	18.22**
THE ODDS RATIOS FOR QUESTION # 6			
	4.56*	0.09	17.30**
THE CONFIDENCE INTERVALS FOR QUESTION # 6			
	531.50	11.46	2546.25
	0.04	0.00	0.12
THE MANTEL- HAENZEL FOR QUESTION # 6			
	16.65**	29.36**	19.57**

ODDS-RATIO ANALYSIS AVIATION 86-87

	IA vs IB+II	IB vs IA+II	II vs IA+IB
THE ODDS RATIOS FOR QUESTION # 1			
	0.85	1.39	0.73
THE CONFIDENCE INTERVALS FOR QUESTION # 1			
	5.09	17.56	16.35
	0.14	0.11	0.03
THE MANTEL- HAENZEL FOR QUESTION # 1			
	0.03	0.56	0.47
THE ODDS RATIOS FOR QUESTION # 2			
	2.14	1.83	0.45
THE CONFIDENCE INTERVALS FOR QUESTION # 2			
	97.87	153.01	63.45
	0.05	0.02	0.00
THE MANTEL- HAENZEL FOR QUESTION # 2			
	0.48	1.77	3.02
THE ODDS RATIOS FOR QUESTION # 3			
	0.17	1.58	0.93
THE CONFIDENCE INTERVALS FOR QUESTION # 3			
	39.30	554.00	491.76
	0.00	0.00	0.00
THE MANTEL- HAENZEL FOR QUESTION # 3			
	3.03	1.08	0.02
THE ODDS RATIOS FOR QUESTION # 4			
	34.09**	0.31	0.93
THE CONFIDENCE INTERVALS FOR QUESTION # 4			
	27105.96	365.51	1568.60
	0.04	0.00	0.00
THE MANTEL- HAENZEL FOR QUESTION # 4			
	19.22**	4.39*	0.02
THE ODDS RATIOS FOR QUESTION # 5			
	1.16	1.10	0.87
THE CONFIDENCE INTERVALS FOR QUESTION # 5			
	2372.58	2704.75	2536.73
	0.00	0.00	0.00
THE MANTEL- HAENZEL FOR QUESTION # 5			
	0.03	0.06	0.11
THE ODDS RATIOS FOR QUESTION # 6			
	0.0	4.38	0.30
THE CONFIDENCE INTERVALS FOR QUESTION # 6			
	0.0	1474588036.99	101593510.59
	0.0	0.00	0.00
THE MANTEL- HAENZEL FOR QUESTION # 6			
	0.49	2.09	1.30

	IA vs IB+II	IB vs IA+II	II vs IA+IB
THE ODDS RATIOS FOR QUESTION # 1			
	0.21	8.00**	0.80
THE CONFIDENCE INTERVALS FOR QUESTION # 1			
	2.12	208.72	43.54
	0.02	0.31	0.01
THE MANTEL- HAENZEL FOR QUESTION # 1			
	5.51*	4.88*	0.13
THE ODDS RATIOS FOR QUESTION # 2			
	0.96	2.73	0.47
THE CONFIDENCE INTERVALS FOR QUESTION # 2			
	131.42	804.52	274.41
	0.01	0.01	0.00
THE MANTEL- HAENZEL FOR QUESTION # 2			
	0.00	0.84	0.72
THE ODDS RATIOS FOR QUESTION # 3			
	0.72	1.52	0.85
THE CONFIDENCE INTERVALS FOR QUESTION # 3			
	522.27	1364.02	933.28
	0.00	0.00	0.00
THE MANTEL- HAENZEL FOR QUESTION # 3			
	0.20	0.42	0.08
THE ODDS RATIOS FOR QUESTION # 4			
	22.80**	0.85	0.06
THE CONFIDENCE INTERVALS FOR QUESTION # 4			
	30180.18	1338.29	108.80
	0.02	0.00	0.00
THE MANTEL- HAENZEL FOR QUESTION # 4			
	23.52**	0.06	11.14**
THE ODDS RATIOS FOR QUESTION # 5			
	0.21	0.79	2.32
THE CONFIDENCE INTERVALS FOR QUESTION # 5			
	536.29	2816.14	11201.37
	0.00	0.00	0.00
THE MANTEL- HAENZEL FOR QUESTION # 5			
	2.50	0.17	2.43
THE ODDS RATIOS FOR QUESTION # 6			
	0.0	0.0	0.0
THE CONFIDENCE INTERVALS FOR QUESTION # 6			
	0.0	0.0	0.0
	0.0	0.0	0.0
THE MANTEL- HAENZEL FOR QUESTION # 6			
	0.0	0.0	0.0

ODDS-RATIO ANALYSIS GROUND 86-87

	IA vs IB+II	IB vs IA+II	II vs IA+IB
THE ODDS RATIOS FOR QUESTION # 1			
	0.79	1.33	0.85
THE CONFIDENCE INTERVALS FOR QUESTION # 1			
	2.72	7.68	7.30
	0.23	0.23	0.10
THE MANTEL- HAENZEL FOR QUESTION # 1			
	0.16	0.35	0.10
THE ODDS RATIOS FOR QUESTION # 2			
	3.25	0.48	1.17
THE CONFIDENCE INTERVALS FOR QUESTION # 2			
	69.53	20.73	90.38
	0.15	0.01	0.02
THE MANTEL- HAENZEL FOR QUESTION # 2			
	1.27	1.21	0.05
THE ODDS RATIOS FOR QUESTION # 3			
	2.20	0.71	0.83
THE CONFIDENCE INTERVALS FOR QUESTION # 3			
	213.47	86.17	123.80
	0.02	0.01	0.01
THE MANTEL- HAENZEL FOR QUESTION # 3			
	1.27	0.42	0.09
THE ODDS RATIOS FOR QUESTION # 4			
	9.42**	0.46	0.41
THE CONFIDENCE INTERVALS FOR QUESTION # 4			
	1686.14	97.69	104.30
	0.05	0.00	0.00
THE MANTEL- HAENZEL FOR QUESTION # 4			
	13.60**	2.38	2.11
THE ODDS RATIOS FOR QUESTION # 5			
	1.04	1.02	0.95
THE CONFIDENCE INTERVALS FOR QUESTION # 5			
	310.42	358.80	389.33
	0.00	0.00	0.00
THE MANTEL- HAENZEL FOR QUESTION # 5			
	0.00	0.00	0.01
THE ODDS RATIOS FOR QUESTION # 6			
	0.0	0.0	0.0
THE CONFIDENCE INTERVALS FOR QUESTION # 6			
	0.0	0.0	0.0
	0.0	0.0	0.0
THE MANTEL- HAENZEL FOR QUESTION # 6			
	0.47	1.87	0.84

ODDS-RATIO CROSS ANALYSIS AVIATION (82-83 vs 86-87)

QUESTION #1
CHI - SQUARE CROSS ANALYSIS
-38.82 -53.24 286.30
MANTEL-HAENZEL CROSS ANALYSIS
5366.67 123.21 759.57

QUESTION #2
CHI - SQUARE CROSS ANALYSIS
848.13 -43.17 11.11
MANTEL-HAENZEL CROSS ANALYSIS
3358.33 -98.87 118.21

QUESTION #3
CHI - SQUARE CROSS ANALYSIS
511.76 3.80 -41.94
MANTEL-HAENZEL CROSS ANALYSIS
-99.67 262.96 25200.00

QUESTION #4
CHI - SQUARE CROSS ANALYSIS
-62.72 48.39 -21.51
MANTEL-HAENZEL CROSS ANALYSIS
120.19 80.41 3300.00

QUESTION #5
CHI - SQUARE CROSS ANALYSIS
236.21 -83.64 1285.06
MANTEL-HAENZEL CROSS ANALYSIS
1313866.67 740850.00 16463.64

QUESTION #6
CHI - SQUARE CROSS ANALYSIS
0.0 -97.95 5666.67
MANTEL-HAENZEL CROSS ANALYSIS
3297.96 1304.78 1405.38

ODDS-RATIO CROSS ANALYSIS GROUND (82-83 vs 86-87)

QUESTION #1

CHI - SQUARE CROSS ANALYSIS

-73.42	501.50	-5.88

MANTEL-HAENZEL CROSS ANALYSIS

3343.75	1294.29	30.00

QUESTION #2

CHI - SQUARE CROSS ANALYSIS

-70.46	468.75	-59.83

MANTEL-HAENZEL CROSS ANALYSIS

-100.00	-30.58	1340.00

QUESTION #3

CHI - SQUARE CROSS ANALYSIS

-67.27	114.08	2.41

MANTEL-HAENZEL CROSS ANALYSIS

-84.25	0.0	-11.11

QUESTION #4

CHI - SQUARE CROSS ANALYSIS

142.04	84.78	-85.37

MANTEL-HAENZEL CROSS ANALYSIS

72.94	-97.48	427.96

QUESTION #5

CHI - SQUARE CROSS ANALYSIS

-79.81	-22.55	144.21

MANTEL-HAENZEL CROSS ANALYSIS

0.0	0.0	24200.00

QUESTION #6

CHI - SQUARE CROSS ANALYSIS

0.0	0.0	0.0

MANTEL-HAENZEL CROSS ANALYSIS

-100.00	-100.00	-100.00

Appendix B

Data blending used in comparing 1982-1983 and 1986-1987 results

AVIATION

Question	1982 Question Number	1982 Response	1983 Question Number	1983 Response
1. Duty Status: Active?	#2	Yes	#8	a
		No		b,c,d,e
2. Collateral Investigation	#3	Yes	#9	d,e,f
		No		a,b,c
3. Training	#4	Yes	#12	b,c,d
		No		a
4. Unfavorable Action	#5	Yes	#10	b to o
		No		a
5. Favorable Action	#6	Yes	#13	b to i
		No		a
6. Other Accidents	#7	Yes	#14	b
		No		a

GROUND

Question	1982 Question Number	1982 Response	1983 Question Number	1983 Response
1. Duty Status: Active?	#2	Yes	#8	a
		No		b,c,d,e
2. Collateral Investigation	#3	Yes	#9	c,d,e
		No		a,b
3. Training	#4	Yes	#12	b,c,d
		No		a
4. Unfavorable Action	#5	Yes	#10	b to m
		No		a
5. Favorable Action	#6	Yes	#13	b to h
		No		a
6. Other Accidents	#7	Yes	#14	b
		No		a

Appendix C

Letter of Instruction (LOI) and questionnaire

for Aviation and Ground (FY86-FY87)

LETTER OF INSTRUCTION (LOI)
Questionnaire Concerning Army Aviation Accident Personnel
(FY 86 - FY 87)

Purpose: The U.S. Army Safety Center (USASC) is conducting a follow-up study to compare with one conducted in 1984 on the subject of postaccident experience of personnel involved in Army aviation accidents.

General: You are requested to complete a copy of the attached questionnaire at for each person listed at Enclosure 2. The analyzed results will be used for accident prevention purposes only. Individuals and units will not be identifiable in this Army-wide statistical study. Information supplied to USASC in connection with this study will be destroyed when no longer needed.

Special Restrictions on Use of This Study Information: Information supplied in connection with this study is not releasable to anyone except for purposes of accident prevention. This information may be released on a need-to-know basis only with the USASC Judge Advocate's approval (AUTOVON 558-3960). Names, social security numbers, or personal data that may appear shall not be released outside the Department of Defense except as provided in the Privacy Act.

All questionnaire data you collect but do not submit to the USASC must be destroyed when you no longer need it.

Instructions for Completing Questionnaire:

1. Accident case numbers, names, and other information on the accidents included in this study are listed at Enclosure 2. Complete a Personnel Questionnaire for each of the named personnel.

2. Reproduce blank Personnel Questionnaires locally (as needed) and submit one completed copy for each above named individual.

LETTER OF INSTRUCTION (LOI) (Contd.)
Questionnaire Concerning Army Aviation Accident Personnel
(FY 86 - FY 87)

3. If an individual is no longer assigned to your unit/installation, request telephonic contact be made with gaining unit (or individual) to obtain the required information.

4. Make every questionnaire as complete as possible. Include partial answers if necessary.

5. Suspense date: 26 August 1988. Completed questionnaires must be received no later than the suspense date.

6. Mail completed questionnaires to:

Commander
U.S. Army Safety Center
ATTN: CSSC-RR (Mr. A. Boyd)
Fort Rucker, AL 36362-5363

7. Points of contact for USASC are:

Mr. A. Boyd or Dr. G. Gamache
Research and Analysis Division
AUTOVON 558-5916/3842
Commercial (205) 255-5916/3842

PERSONNEL QUESTIONNAIRE (Contd.)
FY 86 87 Aviation Accidents

11. As a result of the accident, what INFORMAL, UNFAVORABLE personnel actions have been taken or are pending? (Check as many as apply.)

TAKEN	PENDING	
☐	☐	a. None known
☐	☐	b. Group censure
☐	☐	c. Undocumented counseling
☐	☐	d. Extra training/extra duty
☐	☐	e. Other informal unfavorable action (specify) ______

12. As a result of the accident, what kind of remedial/corrective/refresher training has been completed (conducted) or is planned? (Check as many as apply.)

COMPLETED	PLANNED	
☐	☐	a. None
☐ ___hrs	☐ ___hrs	b. Unit training
☐ ___hrs	☐ ___hrs	c. Individual training
☐ ___hrs	☐ ___hrs	d. Other (specify) ______

13. What FAVORABLE personnel actions have been taken since the accident? (Check as many as apply.)

☐ a. None known

☐ b. Promotion (specify date) ______

☐ c. Selection for promotion (specify date) ______

☐ d. Selection for command (command/date) ______

☐ e. Selection for higher military or civilian school (school/date) ______

☐ f. Awards (specify award and date) ______

☐ g. Selection for competitive assignment (assmt/date) ______

h. Appointed on orders as:
- ☐ (1) Pilot-in-Command (PIC) (specify date) ______
- ☐ (2) Instructor Pilot (IP) (specify date) ______
- ☐ (3) Standardization Instructor Pilot (SIP) (specify date) ______
- ☐ (4) Instrument Flight Examiner (IFE) (specify date) ______
- ☐ (5) Test Pilot (TP) (specify date) ______
- ☐ (6) Additional aircraft qualification (aircraft/date) ______

☐ i. Other (specify action/date) ______

14. Involvement in other accidents:

☐ a. None known

☐ b. One or more (specify date, type, and involvement in each accident) ______

______

______

15. Comments (optional): ______

______

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

POC: Point of Contact for information on this questionnaire:

Name: ______ Date: ______

Duty position/title: ______

Phone Number: AUTOVON ______

COMMERCIAL ______

THANK YOU.

LETTER OF INSTRUCTION (LOI)

Personnel Questionnaire for Army Ground Centralized Accident Investigations

(1 Oct 85 - 20 Oct 87)

Purpose: The U.S. Army Safety Center (USASC) is conducting a follow-up study to compare with one conducted in 1984 on the subject of postaccident experience.

General: You are requested to complete a copy of the attached questionnaire for each person listed at Enclosure 2. The analyzed results will be used for accident prevention purposes only. Individuals and units will not be identifiable in this Army-wide statistical study. Information supplied to USASC in connection with this study will be destroyed when no longer needed.

Special Restrictions on Use of Subject Study Information: Information supplied in connection with this study is not releasable to anyone except for purposes of accident prevention. This information may be released on a need-to-know basis only with the USASC Judge Advocate's approval (AUTOVON 558-3960). Names, social security numbers, or personal medical data that may appear shall not be released outside the Department of Defense except as provided in the Privacy Act.

All questionnaire data you collect but do not submit to the USASC must be destroyed when you no longer need it.

Instructions for Completing Questionnaire:

1. Accident case numbers and other information for the accidents included in this study are listed at Enclosure 2. All personnel with a causative role, as determined in the accident investigation report, are listed on this enclosure. Complete a Personnel Questionnaire for each of the listed personnel.

2. Reproduce blank Personnel Questionnaires locally and submit one completed copy for each above defined individual.

LETTER OF INSTRUCTION (LOI) (Contd.)

Personnel Questionnaire for Army Ground Centralized Accident Investigations

(1 Oct 85 - 20 Oct 87)

3. If an individual is no longer assigned to your unit/installation, request telephonic contact be made with gaining unit (or individual) to obtain the required information.

4. Make every questionnaire as complete as possible. Include partial answers if necessary.

5. Suspense date: 26 August 1988.

6. Completed questionnaires must be received not later than the above suspense date.

7. Mail completed questionnaires to:

Commander
U.S. Army Safety Center
ATTN: CSSC-RR (Dr. G. Gamache)
Fort Rucker, AL 36362-5363

8. Points of contact for USASC are:

Dr. G. Gamache or Ms. M. Thompson
Research and Analysis Division
AUTOVON 558-3842/5916
Commercial (205) 255-3842/5916

PERSONNEL QUESTIONNAIRE (Contd.)
1 Oct 85 - 20 Oct 87 Army Ground Centralized Accident Investigations

11. As a result of the accident, what INFORMAL, UNFAVORABLE personnel actions have been taken or are pending? (Check as many as apply.)

TAKEN	PENDING	
☐	☐	a. None known
☐	☐	b. Group censure
☐	☐	c. Undocumented counseling
☐	☐	d. Extra training/extra duty
☐	☐	e. Other (specify) ________

12. As a result of the accident, what kind of remedial/corrective/refresher training has been completed (conducted) or is planned? (Check as many as apply.)

COMPLETED	PLANNED	
☐	☐	a. None
☐ ____hrs	☐ ____hrs	b. Unit training
☐ ____hrs	☐ ____hrs	c. Individual training
☐ ____hrs	☐ ____hrs	d. Other (specify) ________

13. What FAVORABLE personnel actions have been taken since the accident? (Check as many as apply.)

☐ a. None known

☐ b. Promotion (specify date) ________

☐ c. Selection for promotion (specify date) ________

☐ d. Selection for command (specify command level & date) ________

☐ e. Selection for higher military or civilian schooling (specify school, course and date) ________

☐ f. Awards (specify award and date) ________

☐ g. Selection for competitive assignment (specify assignment and date) ________

☐ h. Other (specify action/date) ________

14. Involvement in other accidents:

☐ a. None known

☐ b. One or more (specify date, type, and involvement in each accident) ________

____

15. Comments (optional) ________

____

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

POC: Point of Contact for information on this questionnaire:

Name: ________ Date: ________

Duty position/title: ________

Phone number: AUTOVON ________

COMMERCIAL ________

THANK YOU.

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